Bachelor's thesis

Industrial Management and Engineering

2018

Azma Mohammed

CREATING A PFEP TOOL FOR THE USE OF INTERNAL LOGISTICS

– Case: Valmet Automotive, Picking Process

TURKU AMK
TURKU UNIVERSITY OF APPLIED SCIENCES

BACHELOR'S THESIS | ABSTRACT

TURKU UNIVERSITY OF APPLIED SCIENCES

Industrial Management and Engineering

2018 | 63, 2

Azma Mohammed

CREATING A PFEP TOOL FOR THE USE OF INTERNAL LOGISTICS

- Case: Valmet Automotive, Picking Process

Plan for Every Part (PFEP) is a lean tool which combines necessary data of all parts related to a specific plant. This is generated to one view which can be accessed through the members of an entire organization in question. PFEP can be then used for indicating the areas of development and the most costly parts of operations, for instance.

As a whole, this thesis aims to create a PFEP tool to enable further development practices in the internal logistics department of a Finnish car manufacturer, Valmet Automotive (VA) locating in Uusikaupunki, Finland. The perspective taken regards to the picking process, and to the parts of Mercedes GLC.

The final PFEP tool to be created has to fulfil three requirements. First of all, it must be functioning and easily updatable. Moreover, it has to be available to be improved regarding other processes of internal logistics, and also to be forwarded to an automatized format, later on.

In the beginning of the paper, the theory is presented regarding logistics and lean, the latter one which is also connected to the ideas behind PFEP in particular. After this, the VA case is discussed including current development methods and specified requirements for the new PFEP development tool. In the last part of the thesis, results are shown with illustrative pictures of the created PFEP, which is then also analysed.

Regarding the created PFEP, the format chosen is an excel. As a base data, forecast demand and work measurement ones are taken advantage of. Both of them have been already available in the organization, and with this project they are now been utilized in a correct way for development purposes. The work done meanwhile is also argumented for specifically, in order to avoid unnecessary data in the PFEP. In addition to a finished PFEP, some ideas for further improvement are also presented in the end.

KEYWORDS:

PFEP, Internal Logistics, Picking Process, Logistics Development, Lean Logistics, Lean Transformation

OPINNÄYTETYÖ (AMK) | TIIVISTELMÄ

TURUN AMMATTIKORKEAKOULU

Tuotantotalouden koulutusohjelma

2018 | 63, 2

Azma Mohammed

PFEP-TYÖKALUN LUOMINEN SISÄLOGISTIIKAN KÄYTTÖÖN

- Case: Valmet Automotive, Keräilyprosessi

Plan for Every Part (PFEP) on lean-työkalu, joka yhdistää kaiken tarpeellisen datan yhden tehtaan jokaiseen osaseen liittyen. Tämä rakennetaan yksittäiseen näkymään, johon kaikille kyseisen organisaation jäsenille annetaan pääsy. Tällä tavalla PFEP-välinettä voidaan käyttää tunnistamaan yrityksen toiminnan kehityskohteet ja eniten kustannuksia aiheuttavat vaiheet.

Kaiken kaikkiaan tämän työn tavoitteena on luoda PFEP-työkalu suomalaisen autonvalmistajan, Valmet Automotiven Uudenkaupungin sisälogistiikan kehitystoimien tueksi. Näkökulmana projektissa on keräilyprosessi ja Mercedes GLC -automallin osat.

Tuloksena syntyvän PFEP-työkalun on täytettävä kolme vaatimusta. Ensinnäkin työkalun on oltava toimiva ja helposti kehitettävä. Luodun PFEP-välineen on oltava siirrettävissä myös muihin sisälogistiikan prosesseihin, minkä lisäksi se on voitava automatisoidakin kehityskaaren edetessä.

Tämän työn alussa teoriaa esitellään logistikan ja leanin kautta. Näistä etenkin jälkimmäinen yhdistetään PFEP-työkaluun liittyviin käytänteisiin. Seuraavaksi keskitytään VA-tapaukseen yksityiskohtaisesti, mihin sisällytetään esimerkiksi nykyiset sisälogistiikan kehitysmenetelmät ja tarkemmat toiveet uuteen PFEP-välineeseen liittyen. Työn päätteeksi projektin tulokset esitellään havainnollistavin kuvin, jotka myös analysoidaan samanaikaisesti.

Projektin tuloksena PFEP-kehitystyökalu laadittiin excel-formaatiin. Lisäksi sen tietopohjaksi asetettiin ennustetarpeen sekä työntutkimuksen tiedot, jotka ovat olleet jo olemassa organisaatiossa valmiina. Tämän työn myötä niitä käytetään nyt oikealla tavalla kehitystoimien edellyttäjiksi PFEP:in kautta. Kaikki PFEP-exceliin lisätty data on myös hyvin perusteltu tässä yhteydessä. Tällä tavalla voidaan välttää turhan tiedon määrää työkalussa. Työn lopussa projektissa valmistuneeseen PFEP-välineeseen ehdotetaan myös muutamia kehitysehdotuksia jatkoa ajatellen.

ASIASANAT:

PFEP, Sisälogistiikka, Keräilyprosessi, Logistiikan kehitys, Lean-logistiikka, Lean-muutos

CONTENT

LIST OF ABBREVIATIONS **6**

1 INTRODUCTION **6**

2 LOGISTICS **11**
2.1 Internal Logistics 12
2.2 Logistics Costs 14
2.3 Information Systems for Logistics 18
2.4 Management and Development 21

3 LEAN AND "PLAN FOR EVERY PART" (PFEP) **24**
3.1 Lean Philosophy 24
3.2 PFEP 31
3.2.1 Management 34
3.2.2 Advantages and Challenges 35
3.2.3 Connections to Lean 38

4 CASE VALMET AUTOMOTIVE **39**
4.1 Internal Logistics 40
4.2 Current Development Methods of Internal Logistics 45
4.2.1 Part Information 46
4.2.2 Work Studies and Balancing 46
4.2.3 PFEP 48
4.3 New PFEP Tool 49

5 RESULTS AND ANALYSIS **52**

6 CONCLUSIONS **56**

REFERENCES **58**

APPENDICES

Appendix 1. Interview with the VA Internal Logistics Development Team

FIGURES

Figure 1. Factors affecting the competences of a business 11
Figure 2. Common processes of internal logistics 12
Figure 3. The division of logistic expenses 15
Figure 4. Expenses of warehousing 17
Figure 5. ERP system connected to SCM and other IS 19
Figure 6. JIT and JIS illustrated 30
Figure 7. The common process of VA internal logistics 41
Figure 8. The picking process of VA 42
Figure 9. The process of execution in relation to the new PFEP created 51

PICTURES

Picture 1. Logistics costs of manufacturing and trading companies in Finland presented as a share of turnover 14
Picture 2. Technology use of logistics service providers in business operations 18
Picture 3. Essential elements of logistics management 21
Picture 4. Different tools of lean manufacturing 26
Picture 5. An illustration of JIS system 29
Picture 6. An illustration of Pick to Sequence 30
Picture 7. Example of how PFEP is connected with the supply chain 32
Picture 8. Part information that PFEP can include 33
Picture 9. An illustration of the PFEP conclusion tab 53

TABLES

Table 1. Example savings resulting from WMS use 20
Table 2. Possible functional roles of PFEP 37

LIST OF ABBREVIATIONS

BOM	Bill Of Materials
ERP	Enterprise Resource Planning
IS	Information System
JIS	Just In Sequence
JIT	Just In Time
KPI	Key Performance Indicator
MRP	Material Resource Planning
OEE	Overall Equipment Effectiveness
PFEP	Plan For Every Part
TCO	Total Cost of Ownership
TPM	Total Productive Maintenance
VA	Valmet Automotive
WMS	Warehouse Management System

1 INTRODUCTION

The definition of logistics has changed over the years. Since 1960s an enormous leap has been taken from treating individual logistics functions separately, towards combining them to a whole entity of supply chain management. To emphasize, the terms “logistics” and “management of supply chain” are nowadays often used as synonymes to one another. (Logistiikkaselvitys 2009.) This shift over the decades gives attention to the integrative nature of logistics and its substantial effects on the functionality of business operations both in detail regarding certain processes, and in general as a whole.

Created benefits are most importantly resulted as the effectiveness of the operations and optimized use of resources. This is however a challenge for many companies as they struggle to integrate their supply chain functions or at worst, they do not even realize the importance of such actions.

One tool to manage and integrate the variety of different functions within the entire supply chain, is to introduce an Enterprise Resource Planning (ERP) system, as chapter two will elaborate further. There are many ways to benefit from the integrative nature of ERP and all the data retrieved from it, one of which is Plan for Every Part (PFEP). Introduced by lean manufacturers, PFEP in a way, links value creation to the entire supply chain (Conrad & Rooks 2016, 7). The aim of PFEP essentially, is to provide easily accessible, valid and current information in one place for many people at the same time, throughout the organization (Harris & Harris 2013, 18). In practice, this means creating one view of all the data seen necessary for each component revolving in one particular plant. All in all, PFEP can be then used for indicating the areas of development and the most valuable areas of operations, for instance. This is further discussed throughout the paper, but in particular in chapters three and four.

As a whole, this thesis aims to have an effect by creating a PFEP tool to enable further development practices in the internal logistics department of a Finnish car manufacturer, Valmet Automotive (VA) locating in Uusikaupunki, Finland. Regarding this PFEP, the format chosen is an excel, while forecast demand and work measurement data are taken advantage of.

During the spring of 2018 VA started manufacturing two Mercedes models side by side. To avoid any misinformation that could be the case in the early phases of launching new operations, the focus of this thesis is directed only towards the parts of Mercedes GLC.

Moreover, only the parts of picking process are in attention. These two restrictions are made to keep the research work lean, and steer clear of deadline issues that could have been an issue due to the wide variety of complex processes of the company.

The main objective set for the project is to construct a functioning and easily updatable PFEP development tool for the picking process while making research on what kind of data is needed for such, and how to access it. Another target is to create the tool to act as a complete PFEP base, that can be further improved to reach beyond picking process towards the rest of the internal logistic processes, and then ultimately forward the entire tool to a more sustainable, automatized format.

On the whole, the paper is started with introducing VA and explaining the taken perspective of logistics, in particular internal one. It is then continued with depicting the background and details considering PFEP in general, and later focused to the VA case on hand. The last-mentioned part includes interviews held with the VA internal logistics development team, while the rest of the thesis is connected to a variety of different articles and literature. In essence, the case part goes further in explaining the current development methods used in the internal logistics department of VA, and also the ideas risen within the company regarding the PFEP tool. The paper is finished with presenting the final results and analysis of the project, suggesting ideas for further improvement of the tool, and concluding the entire project in the end.

For confidentiality reasons, some information is left outside the published version of this paper. This should be kept in mind especially with chapter five presenting the results and analysis, but also in chapter four and even in relation to conclusions and recommendations in the end. In each part, the eliminated confidential information is replaced with a short, general description of the content of the part, with no details. The attempt is to remain the overall cohesive approach throughout the paper, with respect for the VA business.

Valmet Automotive

Valmet Automotive, at the time known as Saab Valmet, has been established in 1969 by the Finnish company Valmet and a Swedish one Saab. The Nordic cooperation started first producing Saab cars in Uusikaupunki, Finland. In 1992, Valmet took over, and since then the Finnish company has collaborated with multiple international vehicle corporations such as Adam Opel AG and Porche AG. Moreover, in the 21st century the company participated in manufacturing alternative powertrains and electric vehicles from which Norwegian Think City, electric golf car Garia and hybrid plug-in car Fisker Karma are examples. Nowadays, VA works together with the German, Daimler AG manufacturing several models of Mercedes Benz since 2013. (Valmet Automotive 2015, 10.)

Today, Valmet Automotive has a culture that values customer success creation, best quality performance and collective ways of innovating, offering manufacturing and engineering services in addition to roof system solutions. All in all, these operations are divided into three different locations: Uusikaupunki in Finland, Osnabrück in Germany and Zary in Poland. (Valmet Automotive 2015, 10.) In relation to this paper, it is necessary to enlarge only on the manufacturing operations of VA, which takes place in Uusikaupunki. For this reason, the information provided further is related to this location only.

In Uusikaupunki, VA represents as the only contract manufacturer of automobiles in Finland and even, one of the three in whole Europe (Nikula 2017). In 2016, the company was consulted to have a turnover of more than 208 million euros employing over 1400 people (Asiakastieto 2016.) Furthermore, the company has been hitting the Finnish headlines often during the last few years as enormous leaps have been taken, especially with the nationwide mass recruitment projects of hundreds of new employees and the continuous attempt to increase production volumes.

In particular, 2017 was an especially good year for VA in Uusikaupunki as it kept announcing positive changes nearly all year long. First of all, the company started working in three shifts while increasing the production volumes according to the plans. This was accompanioned with almost doubling the employee amount. (Bhose 2017.) In detail, the recruitment of additional 2000 people was done in only 9 months which gave the company even more media attention, and a Finnish Growth award on top of everything (Vuorela 2017). During this, two car models were under manufacturing in parallel for the first time in the history of VA: Mercedes A-series and Mercedes GLC. At the same time VA also already had the largest robot welding shop in Finland with nearly 600 robots (Raunio 2016). This latter detail highlights the high production volumes and efficiency which both depict VA in these few years in particular. During 2017, VA even reached a new production record with 90 000 manufactured cars, compared to the 70 000 cars of the previous record two years prior, in 2015 (Valmet Automotive 2018a). In a bigger picture, VA has had a substantial impact by increasing export activities of Finland. To be precise, the export of automotives increased by 260 % from July 2016 to

July 2017, achieving the value of 190 million euros. (Bhose 2017.) In a national level, the impact that the company has had to the country, and also to the society, is remarkable in every way so far.

A lot of this success can be explained with the way VA manages its operations. Relating to this, logistics point of view needs to be taken to support the perspective presented in this thesis. The strategy set for the logistics and production management of the whole VA, resonates to throughout the company, also all the way to Uusikaupunki. This strategy emphasizes the optimization of cash and information flows in particular. The achieved objective here is the lean material flow for example, with optimizing the stocks using Just-In-Time methods. Altogether, the company has a way to transfer orders to part and material orders, that are then sent to part suppliers. As the part and material orders are connected with car orders, the production can be modified regarding the customer need in a flexible way. (Valmet Automotive 2018b.)

One way to put emphasis on increasing flexibility within the company, is to move once outsourced operations inhouse again. This is often the case with most important business functions. Regarding VA in Uusikaupunki, such measures were taken few years ago with the internal logistics department answering for the functionality of the whole logistics operations within the Finnish manufacturing plant (Valmet Automotive 2016). In detail, VA has operated the internal logistics inhouse since 2016 due to the fact, that the effect of the department has only increased along the years while the production volumes have become even higher, especially with the parallel production of two different Mercedes models. By owning its own internal logistics department the company can offer more flexibility and has more room to grow as the strategy has set for the future. (Valmet Automotive 2016.)

When it comes to what the future of VA represents, nearly all signs are growth related. The aim to grow as a company seems to be what both the company itself, media and people is expecting. Since early 2018, the company has continued to manufacture two car models in parallel for the second time as the Mercedes GLC has been accompanied by a new Mercedes A-series model. Production-wise the volumes for the year are set to a new record of 150 000 cars (Kankare 2018). In comparison, the current record and accomplished production for 2017 is 90 000 vehicles (Valmet Automotive 2018a). During this year, VA will be also growing its employee amount even further and is seen to become the largest factory in Finland by the end of 2018 (Nikula 2017). According to the latest estimate, the number will be around 4500 people which stands for employing another 1000 people during this year (Lehtilä 2018).

Furthermore, the future appears to be secured in other ways as well with different new operations from some of which are already announced. One of them is related to lithium battery production started with Avant Tecno (Valmet Automotive 2017b). Another one is the strategic partnership regarding the electric car inspired innovations with CATL, a provider of battery solutions (Valmet Automotive 2017a).

In relation to all these changes, accurate data management will get even more important for VA as argued in the article of Talouselämä by Matti Kankare (Kankare 2018). The PFEP project presented in this thesis is, in a way, supporting this thought as well by using the available data, and providing a tool for the internal logistics management and development. The more accurate and on-time the used data is, the more development can be made enabling the wanted growth in an effective way.

2 LOGISTICS

In order to give a basis for the thesis project, it is essential to start with the elements of logistics, the internal with particular focus. After this, the focus continues towards the expenses, informations systems and management and development practices related. All of this, is then connected to the VA case and PFEP creation later in chapter four.

Logistics all in all is one of the most important set of processes within a company. It can be defined to start from the sourcing of raw materials, parts and other products needed for the operations, which can be further divided into purchasing, transportation and storaging. After sourcing, the management of production, sales services for finished products and distribution follows. In addition, providing the after sales services are often included in the process as well as a part of logistics chain. (Karhunen etc. 2004, 23). The essential idea of logistics, is to manage all these processes in a way that the end result is of the highest quality possible, with the most affordable way for an enterprise (Karhunen etc. 2004, 23.) In fact, in case of successful optimization, this kind of approach can often create a remarkable advantage for a company. It can even end up creating a major compentence for the business against competitors and even disruptors.

As an example, regarding the largest Finnish companies in trading, approximately 43 % of the competences relate to their logistics strategy. Following the trend, the number for manufacturing companies is remarkable as well, with 35 %. (Logistiikkaselvitys 2012.) Competences often result from an unique management of expenses, speed or quality, all three of which are related to one another. This is illustrated further with Figure 1. (Sakki 2003, 17).

Figure 1. Factors affecting the competences of a business (Sakki 2003, 17).

2.1 Internal Logistics

In the following, internal logistics is further explained shortly, after which the process of picking process within it, is elaborated on. This, to create a more suiting basis for the case on hand, which closely relates to the picking process.

While logistics as a whole stands for a wider set of processes, internal logistics takes a more narrow view with focusing in the logistic actions taken within the borders of the warehouse or the logistics center only. As can be seen from Figure 2, the process here starts as the truck or the trailer is being unloaded, and ends as the end-product is finished and further custom transportation methods are taken care of. As a whole, internal logistics can be divided with a wider perspective as well to include different operative phases from reception to delivery, which all are being managed, measured and developed in effectively thoughout the way. (Lahtinen & Pulli 2012, 85.)

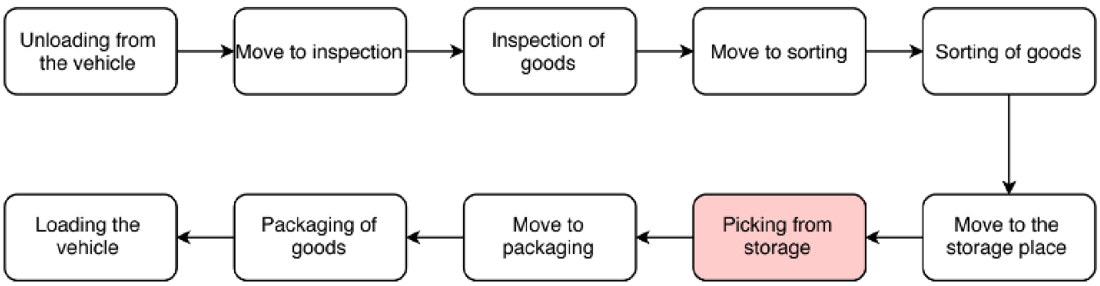


Figure 2. Common processes of internal logistics (Hokkanen & Virtanen 2013, 13).

Picking Process

Picking process is common for all warehouses, and its functions often even require the most amount of work within the internal logistics point of view. Industrial picking process is essentially depicted as picking items from the storage area straight for the customer or semi-manufactured raw materials to the production line. Traditionally, the picker has a picking list printed which containes the material amount, location and label row-wise. (Hokkanen & Virtanen 2013, 35-36.)

There are two distinctive methods that are used in to carry out picking. The first one relates to picking where the picker goes to the item to be picked. In contrast, the other one demands the required item to come to the picker. (Karhunen etc. 2004, 378.)

The last-mentioned method takes place for instance in automated warehouses which typically are high-rise storehouses with automatic lifts. Another example is a horizontal warehouse where the picker operates in the end of the main aisle shelves, and the orbiting place of storages bring then the requested items to the picker according to the need determined in prior. (Karhunen etc. 2004, 378.)

Picking constructed with the picker going to the needed item is however more commonly used method than the previously mentioned one. This can be further divided in two categories according to the way the items are sent to the packaging and dispactching department. One group is formed by those items which are transferred with a conveyor locating either in the floor or the ceiling. In a way, the conveyors are used to get containers emptied by the packaging and dispatching department, in order to fill them now with new items to be then transferred and sent again, back where it first came from. In contrast, the other category requires the picker to move independently to the wanted items, with or without the help of different trucks. (Karhunen etc. 2004, 378.)

The conditions for an effective picking process are essentially determined with a functioning locator system and well designed picking routes. The latter one is usually formed by indicating the items of the highest demands which then leads to placing them in the beginning of the picking routes keeping the distances minimized as a result. (Karhunen etc. 2004, 378.) This kind of approach eventually leads to a lean and wasteless way of work, which is the start of an efficient and well optimized picking process.

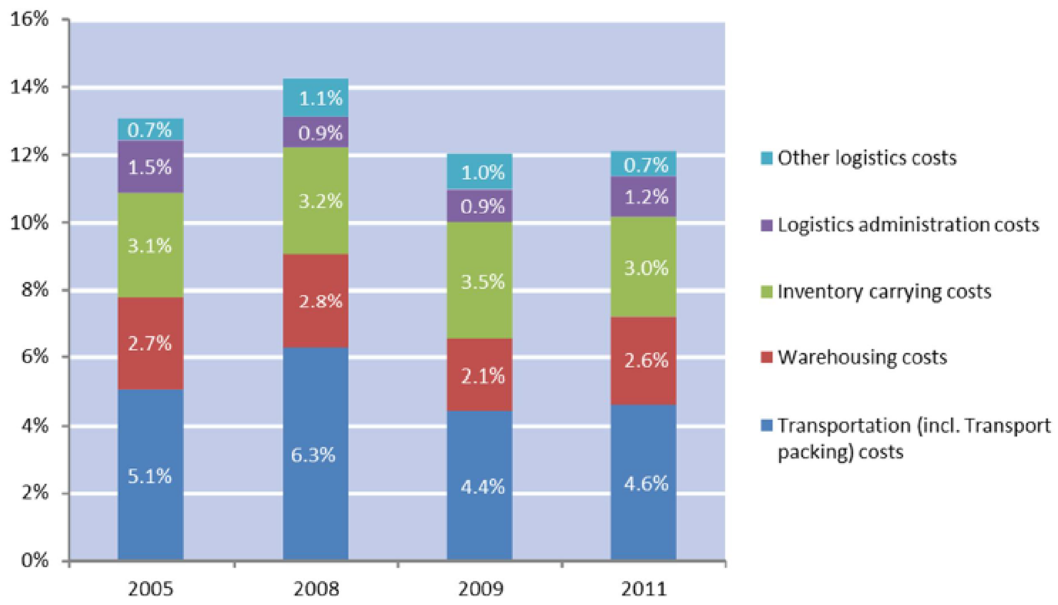
However, in order to have a well-functioning process as a whole, other details must be put in consideration in addition. One aspect to be noticed also, is related to the weight of the items (Karhunen etc. 2004, 378). This way, the heaviest items are to put in the beginning, and the most fragile ones in the end of the picking route. The composition avoids having heavy items on top of fragile ones during the picking (Karhunen etc. 2004, 378). Thus, the picking process and especially the design of it, adds value to the business by assuring higher quality and less damage within the process.

There are several key components regarding the most efficient picking processes. First of all, when the picking process has a well functioning locator system and picking route, the data system can then print customer orders in a way that the items of demand are in order, according to the progress of the picking route in attention. (Karhunen etc. 2004, 378.) Another component is related to having the number of items picked as high as possible in relation to the distance taken in each situation. The last element to be taken in account is to update the picking addresses to respond to the changes in the demand. (Karhunen etc. 2004, 379). This way, all tasks can be developed with the arguments of the most current data which in its own way leads to higher efficiency.

2.2 Logistics Costs

The expenses of logistics are a substantial part from all the costs related to business operations. However, it is also clear that having well-desgined logistics functions affect the company in a positive way by optimizing the use of resources in general, giving attention to efficiency and also adding to its competences, these amongst other advantages.

To be precise, in 2011 logistics costs were consulted as a whole to account for around 12.1 % from the annual turnover of Finnish companies, as can be calculated from Picture 1. Following the trend presented by previous years, the transportation costs had the highest expenses once more with 4.6 %, and inventory carrying costs the second highest with 3.0 % in relation to the annual turnover. (Logistiikkaselvitys 2012)



Picture 1. Logistics costs of manufacturing and trading companies in Finland presented as a share of turnover (Logistiikkaselvitys 2012).

Logistics expenses are however not to be treated as a simple expenditure item. Instead it should be thought as a part of the operating costs, which in a way enable business operations (Logistiikkaselvitys 2012). Furthermore, it is necessary to bear in mind that the logistics costs should be also always seen in detail, to avoid inaccurate information. The differences can be remarkable when dealt with different fields or, either organizational or productional structure (Logistiikkaselvitys 2012). This is why, the precentage of logistics costs from the annual turnover is not enough of a tool to indicate if the logistics are well handled or not within a company (Logistiikkaselvitys 2012).

When identifying a variety of logistics expences, it is noticeable that they can be defined and divided in several different ways, some of which have wider perspective and some narrower. Regarding this paper, the following divison seen in the next page as Figure 3. is chosen to give more insight on the matter.

The model divides logistics expenses into direct or indirect costs with a view of optional / general costs, or operation related ones. Direct costs are closely tied to the logistics operations, while indirect ones are more of a challenge to define. Indirect costs which are related to the operations have more physical visibility and therefore are easier to recognize. The allocation of indirect costs is however more difficult to be be seen as they are often related to the internal functions which are then possibly connected to different operations. (Logistiikkaselvitys 2012).

	direct logistics costs	indirect logistics costs
optional or general costs	inventory carrying costs	costs of lost sales
	value of time	costs of customer service
	expenses of IT use	non-marketability
		IT upkeep and purchases
related to operations	transportation (freight)	packaging materials
	material handling	packaging
	costs of storaged products	capital costs of logistics furniture and estate
	additional costs from fairways etc.	administration
	costs of documents	
	cost of direct telecommunication	

Figure 3. The division of logistic expenses (Logistiikkaselvitys 2012).

Expenses resonating from warehousing, as mentioned in Picture 1. are consulted as the third most expensive logistics cost. In the following, this group of expenses is explained in detail since they relate to the internal logistics perpective taken in this thesis.

Warehousing, meaning handling and storing items cause operational costs. This includes the capital expenses or rent payments for the warehousing area. Other associated and essential costs are related to all the furniture within the warehouse, such as shelves and containers, electricity, insurance and the maintenance to mention few. (Sakki 2003, 61.)

One of the most important expense of warehousing is the storage cost. This relates to the costs of the storaging place but also to the expenses of the production and sales areas which are connected to the storaged items. Often, nearly half of these areas are covered with items. The situation could be even so that there is no separate storaging area and the whole plant or store is a place of storing. The following mentioned formula can be used in calculating the share of storage cost. (Sakki 2003, 61.)

$$share\ of\ storage\ costs = \frac{costs\ of\ storaging}{turnover/value\ added}$$

Another key expense in warehouses is the one of material handling. Throughout a company, two handling processes can be identified. The first one includes reception, inspection, sorting, marking, move to the storage place, while the other one starts from picking and continues with packaging, the preparation of the order and sending. The costs of phases differ according to the nature of the handling item and operation. This can be calculated in detail with the formula presented below, which takes into account both the storaging place but also the production and sales areas in case they are used as storaging area as well. (Sakki 2003, 62.)

$$reception\ and\ sending\ events/day = \frac{number\ of\ events}{number\ of\ work\ days}$$

To go further, the most expensive cost within a warehouse must be then reveiled. According to the Figure 4. presented in the next page, human resources account for the most expensive part when it comes to the costs of warehousing. As HR represents with 56.6 % of the warehousing expenses in total, building and site is left second with 28.7 %. (Intolog 2018, Aminoff etc. 2004.) Therefore, from the formulas presented above, material handling can be interpreted as more expensive. This, as it mainly consists of salary expenses, all add-on costs included (Sakki 2003, 62).

Moreover, when giving attention to the picking process within internal logistics, the function can account for up to 55 % of the operating cost of the warehouse, with 50 % being labour involvement related to travels to, between and from locations. (Richards & Grinsted 2016, 282).

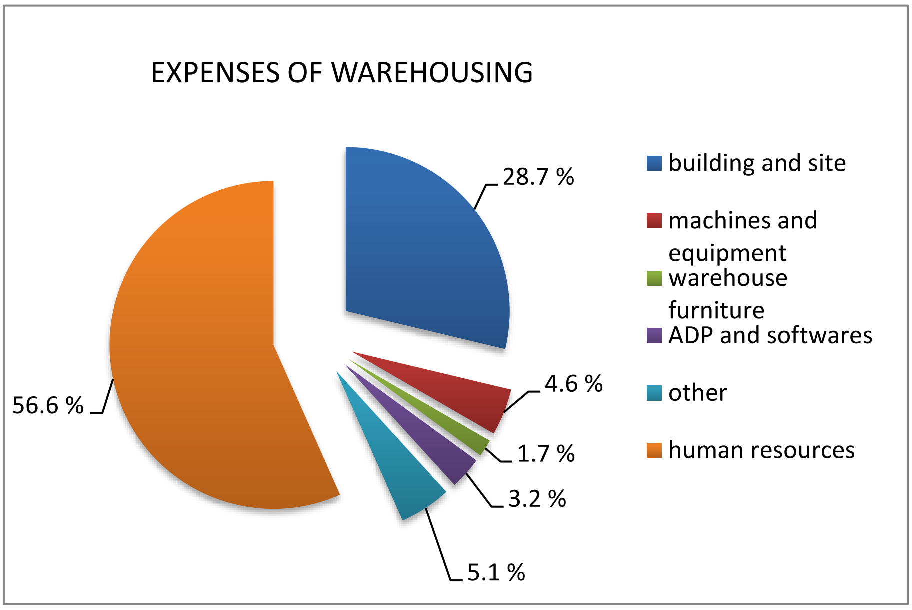
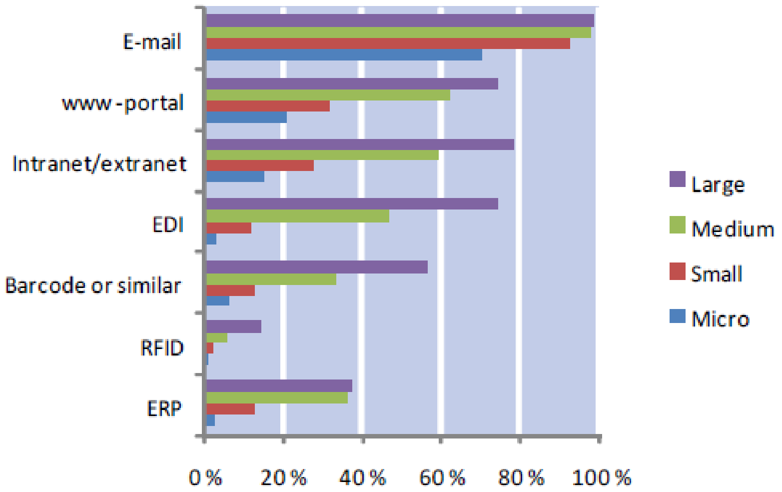


Figure 4. Expenses of warehousing (Intolog 2018, Aminoff etc. 2004).

2.3 Information Systems for Logistics

Different Information Systems (IS) are needed in each enterprise for a variety of functions. Essentially, the idea is to offer the best possible service for customers in question. These kind of systems in a way ensure the fulfilment of those objectives that the company has set, or at least makes it easier to achieve. Eventually, several departments leverage from the information given by the systems in use, in particular when intergrated.

As seen from the Picture 2. there are differences in the use of IS depending on the size of the company. Without an exception, the largest companies use more technologies in their businesses. For instance, ERP systems are used by 30 % - 40 % of the large companies while in comparison, only 10 % - 20 % of the small and 5 % - 10 % of the micro businesses recognize ERP. (Logistiikkaselvitys 2009.)



Picture 2. Technology use of logistics service providers in business operations (The Ministry of Transport and Communications 2009).

In relation to this thesis, ERP and Warehouse Management System (WMS) are both considered as the most important IS for the project. This is why they will be given more attention as follows.

ERP in essence, describes a wide range of particular information systems that are used for managing the company as a whole. Typically, ERP is designed to have one common database which is then used by a variety of modules, such as order management, financial management and warehouse and material management. One database enables the current data accessability and transparency of information throughout the organization. On the other hand, it is obligatory to have all information correct and updated especially regarding the basic information, such as material and production resources. (Logistiikanmaailma 2018a.)

On a bigger picture, systems support different processes of enterprises. As presented from the Figure 5. below, ERP is closely connected to Supply Chain Management (SCM), Manufacturing Execution System (MES) and Product Data Management (PDM), in particular. Furthermore, the figure also clarifies that ERP supports business operations in the planning level in particular while some in the operation level as well. The attention is thus given to the processes of offer and sales in addition to order and delivery. (Karjalainen etc. 2001, 6.)

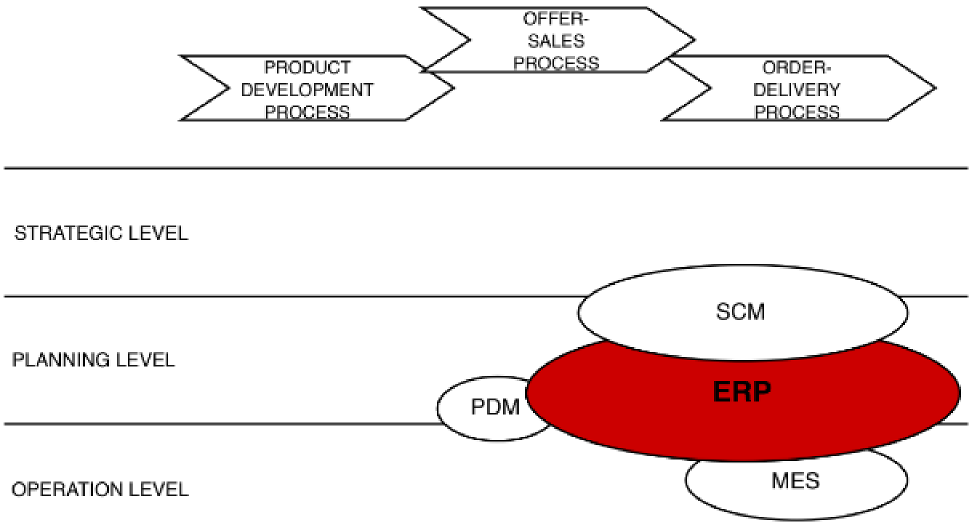


Figure 5. ERP system connected to SCM and other IS (Karjalainen etc. 2001, 6).

The requirements for ERP systems differ depending on a company. In essence, having an unique way of doing business and treating business processes as separate entities makes the proper desing and use of IS difficult. In relation, networking with another company adds up to this, making the integration of multiple systems challenging. As a whole, ERP implementation requires resources and time which should to be taken into account before beginning the project. If the operations are based on flexibility, the system needs to be then created this detail in mind as well. (Logistiikanmaailma 2018b.) Otherwise, the use of information will be inaccurate. In general, Small and Medium-Sized

Enterprises (SMEs) tend to have more of this kind of challenges in comparison with larger enterprises (Logistiikanmaailma 2018b).

Another IS in attention of this paper is WMS which often is included in the general ERP system of the business. WMS aims to manage both warehousing and operations related expenses in addition to the obligations related to the offerred service level. Within the warehouse operations management, the replenishment of the storages and their lot sizes are defined. In detail, the following functions are included to a well-operating WMS: transfer of materials and products, reception, move to the storage place, picking, packaging and delivery. (Logistiikanmaailma 2018c.)

The use of some kind of WMS has many advantages. First of all, as presented in the previous chapter, over 50 % of all logistics cost are due to the expenses of human resources. This is why, the optimization of employee amount and their efficiency is particularly essential, and is one of the objectives of WMS to achieve. In fact, after the learning cure, cost savings are between 10 and 35 per cent when it comes to the effect that WMS has to the labour utilization (Richards & Grinsted 2016, 54). This, and other cost savings by WMS are introduced in Table 1.

	Potential cost savings (%)
Labour utilization	10-35
Inventory reduction	5-30
Floor space utilization	10-30
Maintenance	0-10
Shrinkage	50-75
Rolling stock	10-20
Increase shipping accuracy to	99+
Increase data entry accuracy to	99+

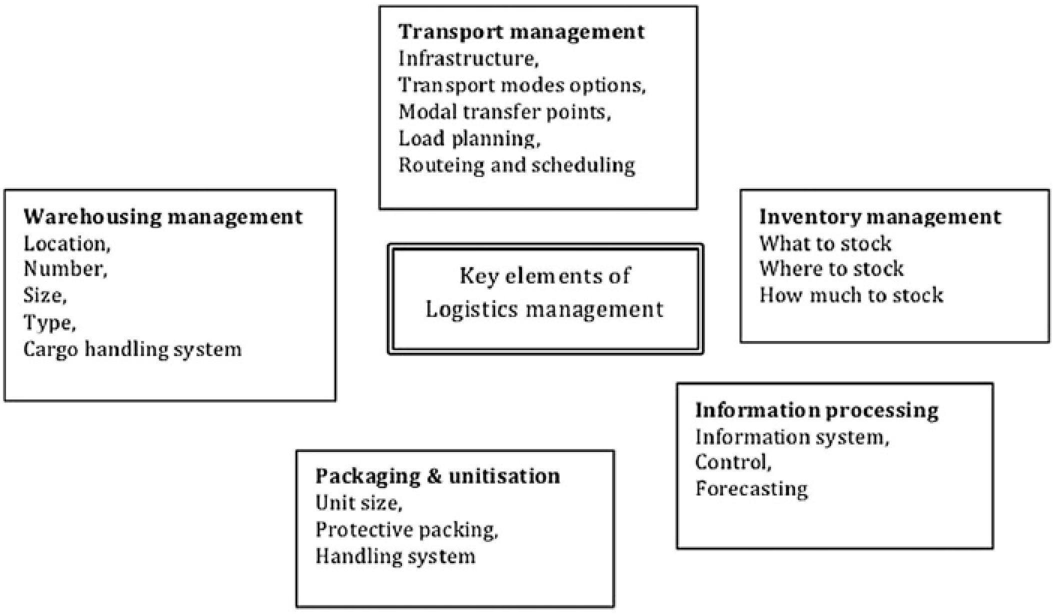
Table 1. Example savings resulting from WMS use (Richards & Grinsted 2016, 54).

In addition, the system can benefit a company in developing the efficiency of the picking process, trace orders and products, and reduce the amount of mistakes within logistics processes of the warehouse. (Logistiikanmaailma 2018c.)

An efficient and well-functioning warehouse operations essentially require a proper WMS. The importance here is eventually in the functionality of the system, whether it is suitable for the business environment and company in question. (Karhunen etc. 2004, 386-388.)

2.4 Management and Development

Regarding management, logistics can be divided in five key elements which are transport, warehousing, inventory, packaging and information processing, as presented in the Picture 3. (Islam etc. 2012). All of them connect when performing the best logistics services possible. However, when it comes to this thesis, the most effect resonates especially from the management of warehousing, inventory and packaging in addition to the processing of information. The latter one which relates to the project on-going, in particular. This is why the mentioned three sides of logistics management are next given further attention.



Picture 3. Essential elements of logistics management (Islam etc. 2012).

Warehouse management in detail includes considerations of location, number and size which are linked to the warehousing policy, type of storage and material handling equipment (Islam etc. 2012). The type of storages and material handling equipment relate to the nature of the item. For example, items which are refrigerated or food products in general, electronics or garments, often require an especial environment in their storaging and handling.

Particularities of inventory management on the other hand relate to the strategic logistics decisions: what, how much and where to stock. This is often confused with warehouse management. To clarify, inventory management focuses on investigating the amount of stock of the product or raw material that is needed whereas warehouse management is restricted with the housing perspective of the stock. (Islam etc. 2012.)

In contrast with the previously mentioned areas, information processing deals in a completely different way. It consist of information systems, forecasting operations and the control of the operations related to IS (Islam etc. 2012.) When it comes to this thesis project, PFEP fits to this section because it combines data from different levels and IS, processing it in the wanted way and then using it for development purposes.

An essential part of logistics management is to have the development aspect alongside all operations. In the following, few concepts are been taken in consideration relating to this paper.

First, it is necessary to introduce the identification of processes creating a basis for actions of development. There are a variety of methods for doing this, but standard flow charting is one of the most powerful ways for improving work or business processes (Richards & Grinsted 2016, 282). In essence, basic flow charting method uses symbols in order to depict operations, activities, decisions, ending and starting points, and links to the next step which can follow immediately on later on the chart (Richards & Grinsted 2016, 282).

Another essential concept is defining Key Performance Indicators (KPIs). The idea here is to select few indicators that relate to the business operations the most. In essence, KPIs are introduced to measure and control performance (Richards & Grinsted 2016, 308). For this reason, using KPIs enable development purposes as well. These can regard to metrics that can be for example related to financial, customer, process or people matters, to mention few.

Introducing WMS, as presented in the previous chapter, is also key, especially for creating efficient operations within a complex warehousing environment (Richards & Grinsted 2016, 52). Therefore, also developing operations become easier with WMS as more accurate data will be available.

3 LEAN AND "PLAN FOR EVERY PART" (PFEP)

There is a clear connection between the essence of PFEP and the ideas of lean. This is why, this chapter is structured by first identifying lean, and then focusing on the details of PFEP. The ideas are further connected to the VA case on hand, later in chapter four.

Altogether, there are several terms defining lean nowadays. In relation to this thesis, the term lean philosophy is being used as a general term through the chapter. This, because lean philosophy can be seen to be connected and furthermore, to be resulting from the use of PFEP. In this perspective, lean often relates to a straight-forward and wasteless, value creating set of operations, to put in a simple way. While lean is further elaborated on during this chapter, in addition, lean thinking and lean Total Productive Maintenance (TPM) are chosen to be mentioned as well, to give more insight and connection point to the PFEP subject.

In the following, the relation between PFEP and lean, is highlighted with primarily, introducing the philosophy behind lean, after which some of the most important lean methods to this project and paper on hand, are discussed. As a next step, the details of PFEP are then made clear, after which the claimed connection to lean is justified.

3.1 Lean Philosophy

Lean became known as short for lean production which was first introduced by the Japanese automotive manufacturers. Its origins go all the way to the Toyota Production System (TPS) that attracted attention with its superiority in the 70s. Since then, TPS has been under continuos development, for around 100 years already. (Six Sigma 2018a.)

In essence, the philosophy aims to apply the principles of quality management to the world of production. This can be seen as focusing on the optimization of the production as a whole, instead of paying attention to minor details. The objective here is then to create value to the customer while putting the needs of the supplier in consideration as well. In practice, lean results as the maximization of customer satisfaction which is an indicator for flow efficiency, and supplier satisfaction that is related to resource efficiency. (Six Sigma 2018a.)

In relation to this project, lean TPM and lean thinking are one of the key ideas to be considerated while indicating the connections to lean. Even though, both ways support same ideology, and have an focus on recognizing the wasteful behaviours and practices within the organization, there are also some particularities related.

Lean TPM as itself, sees the root cause of waste with an short-term perspective which tolerates inferior reliability. Moreover, TPM aims to use improved effectiveness towards increasing the customer value. In detail, the idea here offers a route map to zero breakdowns and continuous improvement when it comes to equipment optimization. (McCarthy & Rich 2004, 25.) Lean TPM is further discussed later in chapter five in connection to VA related methods.

On the other hand, lean thinking focuses on different sides of the same issues. One essential point is to seek for reliable processes that support the objectives of the company. However, what is given most attention is especially related to the identification of the value creating areas from the operations. (McCarthy & Rich 2004, 25.)

Furthermore, lean thinking continues to define five key principles which all especially consider lean manufacturing. One of them is to specify the value that is perceived by the customer. The following ones are to identify the value stream, and to make the value flow through it. Another principle is to pull the value from the value stream, and finally to strive for perfection. All in all, these five principles define the philosophy behind lean in particular. (Lean Manufacturing Tools 2018a.)

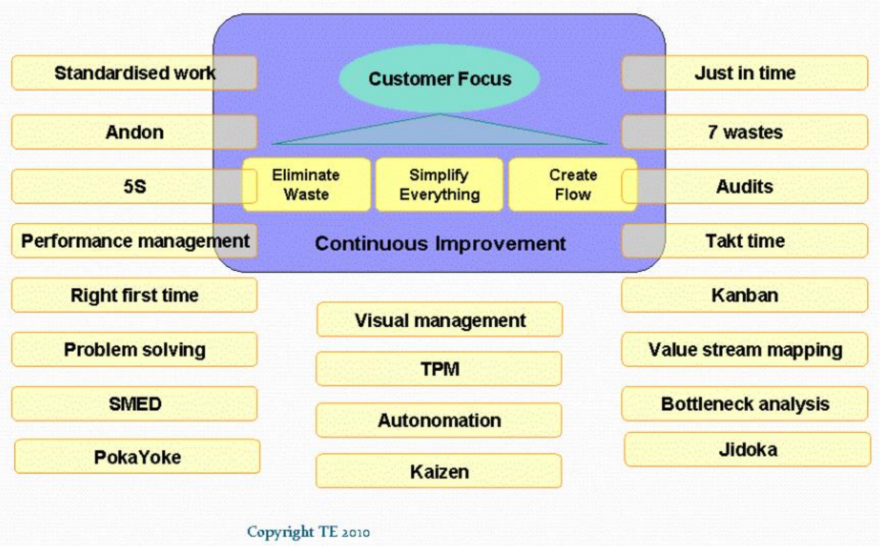
In the following, some of the most important methods and tools are presented in relation to this project. First of all, the ideas of lean material management and lean manufacturing are discussed. Then, Kaizen, different types of wastes, and the terms Just-In-Time (JIT) and Just-In-Sequence (JIS) are given attention, after which the focus continues to six sigma in the last part. All of these, have an angle to this project, either with the way VA operates at the moment, or how PFEP has an effect as enabling development opportunities towards leaner operations, for example. To emphasize this, the connections are drawn in the following, chapter four.

Lean Material Management and Lean Manufacturing

To direct the focus towards lean, it is first important to elaborate on lean material management which in essence, is in fact guided by lean principles. The use, application and effectiveness of lean techniques can be reapplied from the original manufacturing perpective. When it comes to material management, lean must consider both the shop floor and the whole supply chain as well. This, to highlight lean thinking and its principles instead of focusing on the used tools only. Moreover, the distictintion from lean manufacturing has to be made in particular. (Flinchbaugh 2005.)

First of all, five essential concepts must me considered when taking a lean approach to material management. The first one relates to avoiding the information blizzard by creating systems that provide only filtered information directed for each individual process, avoiding excess information handling, and this way also unefficiency. Another idea is eliminating white space that results from not integrating process steps with each other: the next activity does not continue exactly where the previous one was left. To emphasize, this is how waste is then created. The third concept regards to right-sizing everything, which essentially is about the balance between expenses and capital requirements. When it comes to the fourth concept, the transportation is given particular attention, as it is suggested to have minimized eliminating wasteful handling processes. Finally, the fifth concept is about moving away from a tunnel vision, and instead focusing on achieving a complete view on the operations and material management. The importance here is that material management is often a hub of information which is connected to the majority of the rest of the organization. To highlight, if material managers do not operate lean transfromations with a complete holistic view, then none of the managers of other functional areas will either. (Flinchbaugh 2005.)

These concepts in mind, the lean manufacturing tools can be then used also to material management operations. Picture 4. gives a general view of these tools which are in the following given further explanation.



Picture 4. Different tools of lean manufacturing (Lean Manufacturing Tools 2018b).

Kaizen

Kaizen is a lean method which essentially involves the workforce for continual improvement of processes throughout the organization. The power laying on Kaizen is measured by the combined power of a variety of creative ideas and small improvements that develop the business forward constantly. Moreover, the objectives here are related to eliminating issues associated with different types of waste within the processes. In practice, every process should be continuously challenged and tested according to Kaizen. The methods used can be for example suggestion schemes, quality circles and self-directed work teams. All of these however, require support from the top management in order to be successful and result as improvements. (Lean Manufacturing Tools 2018c.)

Seven types of Waste

Waste is what Kaizen and other lean methods attempt to eliminate from the operations of the business. First of all, it is essential to investigate the importance of waste removal before presenting different types of waste. To put simply, waste is something that does not add value to the business. (Lean Manufacturing Tools 2018d.) On the other hand, any other actions that have an negative effect to the operations, can be also seen as waste.

As price is often an important tradable in the market, it is important to have the costs of the business as low as possible. This is why, by eliminating wasteful elements from the processes, a lot of costs are cut at the same time, which in the end, benefits the enterprise. Moreover, the customer satisfaction is more often achieved better with waste elimination, as the processes become more lean and straightforward. (Lean Manufacturing Tools 2018d.)

There are three types of waste according to lean, *muda*, *mura* and *muri*. The first one stands the famous seven wastes identified by lean. It relates to all the activities or processes that do not add value to the business. These can be also described as physical waste. (Lean Manufacturing Tools 2018e.) Seven different mudas are: tranportations, inventory, motion, waiting, overproduction, over-processing and defects. Nowadays, failing to use talents, resources or by-products within the organization, is also seen as wasteful actions, and are added to the list. Another type of waste is Mura which explains the waste of unevenness or inconsistency. This is often driven by muda, and can be seen for example as a failed attempt in converting fluctuating demand to more even one for production purposes. Muri on the other hand means overburdening which in practice is to cause unnecessary stress to the organization, either to the employees or the processes. The reason for this lays behind Mura and, for example, lack of training and unclear or non-systematic ways of working. The three different types of waste are all connected to each other: muda is caused by mura, and mudas are symptoms of failure in tackling mura and muri. (Lean Manufacturing Tools 2018e.)

Just-in-Time and Just-in-Sequence

One way to eliminate waste is with introducing JIT to the operations which is a management philosophy which regulates production according to what the customer wants, when they want it, in the requested quantities and locations they want it. Moreover, the idea of JIT is not to cause any delay or stocks in the inventory. As a result, resources can be concentrated to fulfilling the actual needs rather than building excess stocks. (Lean Manufacturing Tools 2018f.)

In practice, the JIT manufacturing system produces only what the next process in sequence needs according to the actual customer need, while in conventional manufacturing the customer need drawn with forecasts. The difference here is that the traditional method produces in large batches as it is believed to make the machines and processes more efficient, which however creates long lead times and enormous amounts of WIP and stock of finished goods of no demand. Another issue is faced, when a customer suddenly orders items that are not at the time in stock. In essence, these systems are run by a Material Resource Program (MRP) that aim to schedule every process in the facility. To prevent difficulties from happening, complex planning is required. (Lean Manufacturing Tools 2018f.)

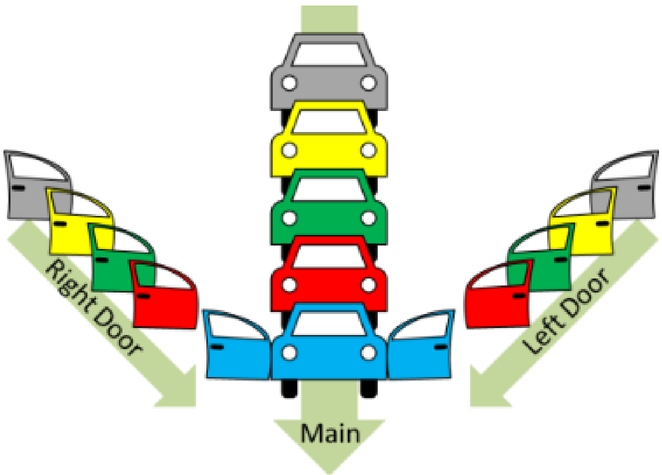
To switch from traditional to JIT manufacturing, some requirements must be fulfilled. First of all, the equipment and machines have to reliable. Furthermore, work cells need to be well designed and a quality oriented workforce must be set. Also, the opertaions within the enterprise are better to be standardized while using pull production. The objective here is to ultimately have a single piece flow, which can howver be difficult to put in practice for some industries. Finally, the production should flow with the beat set by the customer. In order to achieve this, the processes must be organized, balanced and planned for the pull. (Lean Manufacturing Tools 2018f.)

There are some essential benefits that JIT results. These are related to reduction in the order to payment time, inventory costs, required space and in handling equipment and other costs. Moreover, JIT reduces lead times and the complexity of planning. In addition, the system also provides imporved quality and productivity while it also highlights problems faster and empowers employees. (Lean Manufacturing Tools 2018f.)

For many industries JIT is not enough however. JIS is one good example of a system that can be combined with JIT seamlessly. This regards to a production method of a more advanced delivery process where parts and components are delivered just in the sequence as they are needed in the line (Pentas 2016). In an ideal scenario, the person only picks the next part in the supply queu for assemply, rather than choosing from different parts. (AllAboutLean 2017.) At the same time, while JIS is in function, feedback from the manufacturing line can be taken into account for transportation matter from and to the process location (Pentas 2016).

While other industries are giving increasing traction to JIS, the use of it in the automotive industry has been a classic example for a long time (Pentas 2016). Since there is a large number of options in automotives, the industry has a base for JIS with low-volume and high-mix production type where every vehicle is slightly different than the next one.

Often, JIS is used for example with the car doors, as they have to match the rest of the car. This is presented in Picture 5. (AllAboutLean 2017.)



Picture 5. An illustration of JIS system (AllAboutLean 2017).

This can be then further applied to other car parts as well, especially with the custom made automotives with particular features that some providers offer. Some part can be still JIT as these particular parts JIS. This, in addition to the the difference between the two, is illustrated in Figure 6.

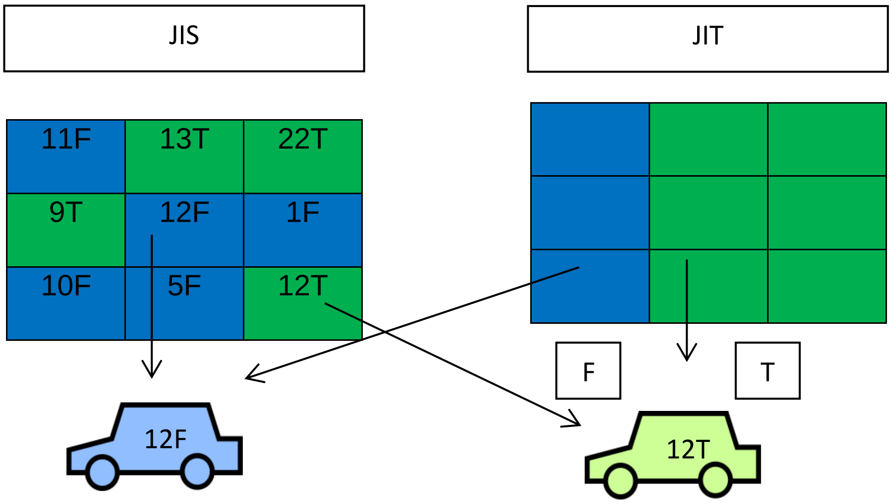
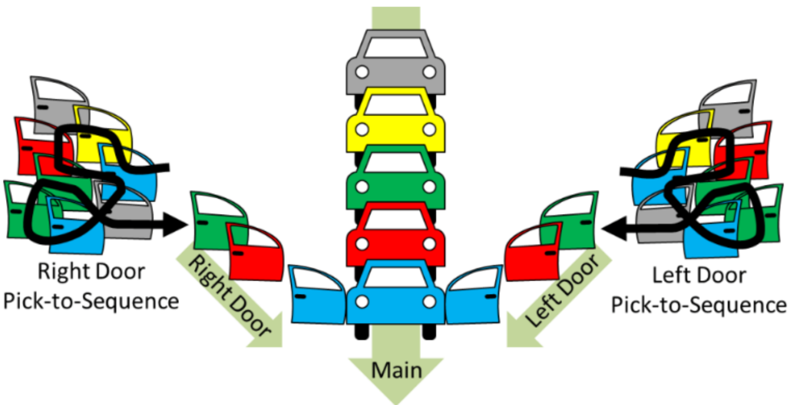


Figure 6. JIT and JIS illustrated (Personal Information. Juhani Kerminen 21.3.2018).

Furthermore, JIS can be implemented in several diffent ways. One of the most common ways is to have a larger inventory from which the components can be chosen to sequence according to the need. Moreover, the method can be adjusted to both high- and low-volume parts. (AllAboutLean 2017.) This can be further developed as pick to sequence, which has a same basis than the previously mentioned use of large inventory method, as illustrated in Picture 6.



Picture 6. An illustration of Pick to Sequence (AllAboutLean 2017).

In pick to sequence a worker or a computer system picks the required components from the inventory and organizes a complete sequence for the assembly. (AllAboutLean 2017.)

Six Sigma

Many methods and tools regarding lean implementation and transformations have been discussed already, while one large group of methods is yet to be presented. Lean six sigma can be described as one of the most important ones to be discussed next in relation to the PFEP project on hand.

Six sigma stands for a group of methods and practices that enable a systematic way of process development. The objective is to minimize the fluctuation in the outcome of the products, which in the end reduces the amount of waste. This can be done with investigating the causalities of the processes, and creating successful, radical instead of incremental, changes to the factors affecting the outcome. The strength within six sigma lays on its scientific nature as it is based on statistics. In fact, its methods are often used in problem solving situations, as an assistance for lean implementations. (Six Sigma 2018b.)

3.2 PFEP

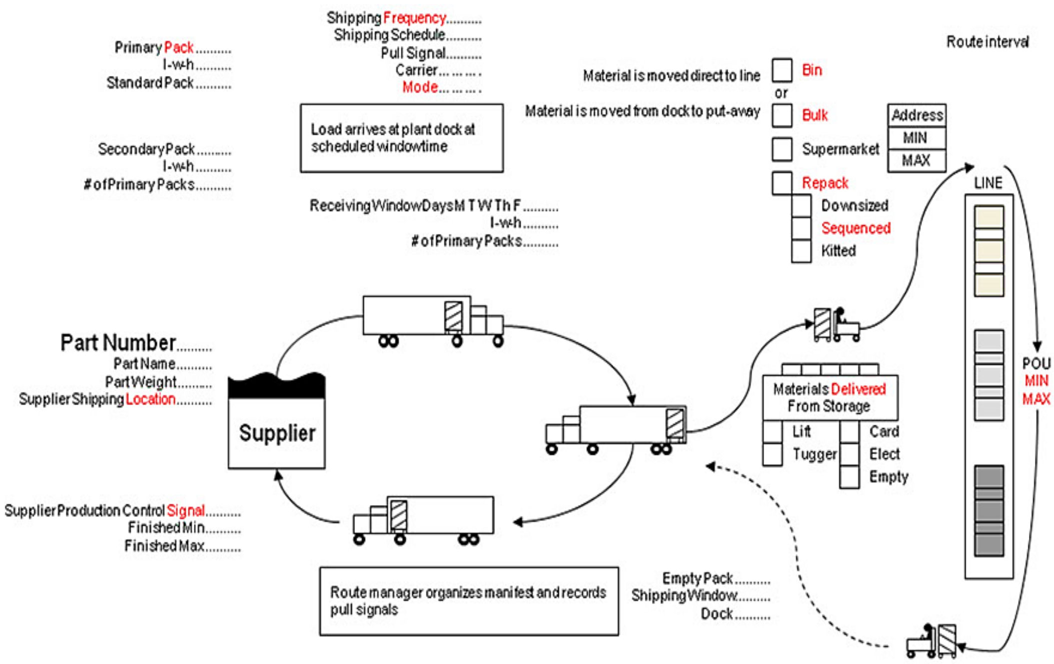
As discussed in chapter two, logistics management and development as a whole, require use of different information systems. One of them, as explained in the previous chapters, is ERP which is a tool that can be used to manage and integrate the variety of different functions within the entire supply chain.

There are many ways to benefit from the integrative nature of ERP and all the data retrieved from it, one of which is PFEP, introduced by lean manufacturers (Chen 2018). While many companies utilize demand and planning strategies based on spreadsheats or some other manual modes of data sourcing, they end up lacking visibility and transparency that in fact, is what PFEP offers (Ostdick 2016.) In this manner, PFEP links value creation to the entire supply chain (Conrad & Rooks 2016, 7).

The objective of PFEP, essentially, is to provide easily accessible, valid and current information about every part in the plant, in one place for many people at the same time (Harris & Harris 2013, 18).

The vital information provided relates then to the entire value chain and includes details, such as the hub of origin, dimensions of the product, packaging, storage condition, location within a warehouse and manufacturing lead time, amongst other. This applies from production to delivery, and regards to each part of the fabrication process, which are all accounted for and recorded. (Ostdick 2016.)

All of this information is often already existing in the organization, while PFEP acts to combine them to one place creating, mentioned visibility to the supply chain, as Picture 7. visualizes (LeanPro 2018). This is further argumented for, later in this chapter.



Picture 7. Example of how PFEP is connected with the supply chain (LeanPro 2018).

Steps to be taken while creating a PFEP

PFEP gives the supply chain leaders a 360-degree view of the inventory and procurement policies on hand. (Chen 2018). To start with, PFEP has to be set for a particular plant only. Thus, it can not subject to multi-plant operations as one. (Ostdick 2016.) In a way, PFEP can be described as the DNA of the facility in attention (Harris & Harris 2013, 17).

Often, the best way to start the creation of PFEP is to put together a particular task force and give only little involvement to line management (Harris etc. 2003, 18). Moreover, in order to go further with the PFEP creation, certain steps can be followed while aiming for the most beneficial PFEP.

First of all, it is essential to start with gathering all the data, which a lot of it is already stored in the ERP system of the plant (Chen 2018). This is best to be put in practice for all parts in the operations, including: consumables, cardboard, dunnage and even hardware. The reason for this lays behind the fact that only in this way the benefiting and, on the other hand, issue-causing elements of the value stream can be seen. (Conrad & Rooks 2016, 18.) The data gathering can be then done either manually or in an automated way, the latter one which offers more validating of data with analytics. The objective here is to highlight areas where data can be improved in order to have analytics more robust. Alongside all this, it is important to have the data in use as reliable as possible. (Chen 2018.) Picture 8. presents some common part details that the PFEP is beneficial to contain. It is however needed to keep in mind, that PFEP represenets a plant in particular, meaning the PFEP can include more, or less from the variety of information available than described below.

- part number;
- hourly usage;
- average daily usage;
- storage and usage location;
- shipment size;
- supplier location;
- box weight;
- part weight;
- box and part dimensions;
- number of parts needed;
- transport carrier;
- transit time, and more.

Picture 8. Part information that PFEP can include (Bartholomew 2015).

The second step is related to analyzing the data. This can be done manually for example with excel by using logic based rules and formulas in the aim of understanding and classifying the data on hand. Another way is to go above excel, towards artificial intelligence (AI) and machine learning platfroms. The idea is to have algorithms in place, and having them upkept both for the time being and also for the future. This is why, perhaps the cloud based systems might be offering more in this perspective. (Chen 2018.)

Third step regards to the complying of the PFEP. The supply chain of the enterprise must be on-line with the rules set by the PFEP. Moreover, the ERP systems must be kept updated, not only once a year or even every quarter, but exactly when it is needed as new procurement policies, demand and inventory plans are changed for example. This approach is important to have, especially with the most important parts within the operations. A good advice is to perform a product-quantity analysis in order to identify the top 5 % of the parts which represent between 70 and 80 % of the monthly spend. After this, all parts can be mass updated every month or quarter. As in the second step, this can be done manually or have it done with more efficient technological solutions. All in all, it is however important to include minimal day-to-day manual management with the PFEP. This is how the efficient functioning of PFEP can be indicated which also gives more advantages. (Chen 2018.)

Furthermore, it is suggested to have a team within the organization working on the steps mentioned. This, essentially because a team within the enterprise perhaps has more long-term objectives while creating a PFEP, which then usually ends up resulting to more advantages for the entire organization. (Chen 2018.)

3.2.1 Management

All in all, maintenance and management of PFEP are important aspects which ensure that there is only one version of truth when it comes to the parts revolving in the plant. In essence, there are two keys that lead to a succesfull use of it to the managed supply chain. First of all, it is essential to include every part to the PFEP, relate it to the Bill Of Materials (BOM) in use and match it to what is actually being built through the value stream. (Conrad & Rooks 2016, 17-18.)

Another aspect regards to the ownership of PFEP. (Conrad & Rooks 2016, 17-18.) In general, it is beneficial to have one point of contact that is responsible for controlling changes, coordinating timing and documenting each change relating to the PFEP. This is crucial because PFEP must be created with the sense of ownership and control. To go further, everyone in the organization should be able to view, access and print the

PFEP or some elements of it. However, it is not suggested that everybody would be also able to alter, delete or even add items to the system. All in all, it is beneficial to appoint a PFEP coordinator, who in essence would work as a point of contact, keeping the information of the PFEP pure, current and more than anything, usable. (Conrad & Rooks 2016, 18.)

In the case of large facilities however, it might be worthy to consider several PFEP assistants in addition. These assistants would then manage the PFEP through the product-family value stream relating to them, alltogether creating a complete PFEP for the entire plant. To conclude, having one PFEP manager, with some assistants, if necessary, usually leads to a more defined PFEP. (Harris etc. 2003, 19.)

3.2.2 Advantages and Challenges

All in all, PFEP results as benefiting the organization, and in particular the facility it is designed for, but also creating some issues in the process. In the following, some most common advantages and challenges are discussed in relation to PFEP.

Advantages resulting from the use of PFEP

Although, many companies already have existing strategies to gather data and informations comparable to that of PFEP solutions, they are however inable to curate, share, review or analyze this data in real-time which then results as disadvantages (Ostdick 2016.) In detail, plants operating without PFEP, often have more inventory, people than they need and they run out of parts more easier and have excessive storage needs in the other hand. (Bartholomew 2015.)

These are some of the issues that are usually tackled with PFEP. Once created, PFEP has many other advantages as well.

First of all, it is essential to take look at the value proposition of PFEP. In practice, PFEP enhances the capacity of the company for agility and flexibility through the whole supply chain. There are three main value propositions that PFEP offers. The first one relates to control which can be related to inventory, distribution or even transportation. All in all, the information that PFEP offers through the supply chain, can be used to adjust and monitor the production and movement of parts without actually interfering to the existing organizational structure. Secondly, PFEP provides greater problem solving methods with giving power to manage the inventory, identify deman solution and implement data-supported solutions. This way it is then possible to identify gaps or bottleneck and take neded actions to avoid or solve these issues thoroughout the supply chain. The third value offered relates to the integration with powerful technology, which happens when incorporating PFEP with the modern BOM strategy. This as a whole is a driver for maintaining a lean and efficient supply stream. To go futher and blending PFEP with other modern computing and processes platforms, the increase and productivity becomes even clearer while making PFEPs capacity higher in providing centralize, accessible entry point for data sourcing and analysis as well. (Ostdick 2016.)

In practice, the analysis drawn form the PFEP can be used for example, as an argument for informed decion-making processes within the organization (Harris & Harris 2013, 18.) In a long run, PFEP also ends up maximizing every inventory euro, by balancing the entire supply chain with as little inventory as possible and minimal shortages. (Chen 2018.) PFEP also helps the plant to realize which category its parts fall into. As a result, the production can be scheduled and run effectively according to the information offered. In fact, when PFEP is fully implemented, it often affects as nearly 50 % of reduction in inventory. (Bartholomew 2015.)

Furthermore, there are also other ways to use the information gathered in the PFEP. For example, they can be used further to manage the material handling system, size markets and storage rack which contains purchased parts and design timed delivery routes and kanbans. (Bartholomew 2015.) Moreover, the information can also act as a tool to equip the operating team as to be better skilled, while the processes itself can be shown possibilities to be accelerated, or even automated. (Chen 2018.)

The use of PFEP alongside other systems, such as BOM management boosts the benefits even further providing adjustment capabilities based on both inventory and demand, at the same time allowing in-depth calculations and analysis to identify gaps within the areas discussed and more. (Ostdick 2016.)

When it come to advantages relating to specific areas of the business, PFEP can be used in many ways. As the subject of this thesis relates to the internal logistics, it is an aim to present this area in particular. Within internal logistics, PFEP can be used to boost especially the planning which includes facility, cell, supermarked layout and internal route development. Moreover, PFEP can also affect the determination of best storage and delivery method in a positive way by argumenting on usage and container quantity. (Conrad & Rooks 2016, 55.)

In addition, the advantages to other parts of the business are presented in Table 2. below. This, to create an overview in how multidimensional PFEP in fact is.

BUSINESS AREA	**ROLE OF THE PFEP**
Sales	forecasts finished goods, scrubs data in the PFEP, standardizes parts and level load demand
Logistics	manages incoming deliveries, water spiders and suppliers
Sourcing	negotiates long term agreements relating to lean and productivity targets and incentives, and removes riggers from MRP
Finance	helps data scrubbing, sets up monthly supplier billing and implements audit controls for suppliers
Production	Follows procedures of the PFEP.
IT	supports systems changes relating to the coding parts from assets to floor stock, flattens the BOMs, helps to scrub data and develops data tool needed to feed the spreadsheet
Supplier Quality	helps in transitioning suppliers and to certifying partnering suppliers towards dock to stock, helps suppliers get lean and ensures process capabilities required, helps with supplier report cards
Production Quality	enables in-process quality controls and plans

Table 2. Possible functional roles of PFEP (Protzman etc. 2016, 17-19).

Challenges related to PFEP

There are several issues regarding the creation and also managing of PFEP. It is however needed to kept in mind, that both the challenges and the solutions to solve them can vary according to the type and the needs of the plant, as PFEP is unique to every facility.

On of the most common, challenges coming across relates to the gathering and compiling the data of hundreds or thousands of parts, in addition to including every part within the plant. One solution could be to start PFEP with one manufacturing cell at a time, as some managers have done in the past. (Bartholomew 2015.)

Another major challenge with PFEP is the tuning of it. This often requires a lot of time and manual excel analysis, which then results as limiting the frequency of optimization. To avoid this, there are some solutions offered by new technologies which are based on lean supply chain best practices. (Chen 2018.)

Furtheremore, as discussed earlier in this chapter, the best way to start the creation of PFEP is usually to put together a particular task force and give only little involvement to line management. This however leads to issues when it comes to the management and maintenance of the PFEP and eventually leads to accuracy problems. (Harris etc. 2003, 18.) For this reason, every enterprise and plant should come up with solutions that best suit their operations in order to tackle this challenge as well.

3.2.3 Connections to Lean

As presented previously in this chapter, PFEP is a key step towards lean organization since it ensures visibility of every individual part movement (LeanPro 2018). Through the supply network, in addition to visibility, also speed is ensured with PFEP, which both relate to some of the most important principles of lean management (Ostdick 2016).

In practice, PFEP can be seen as a first step in creating a lean material-handling system, and even as a essential element when moving the enterprise towards lean transformation. The reason for this, mainly lays on the fact, that PFEP gatheres all the information related to the parts to one place which increases the detailed attention put into the materials, parts and operations in this perspective. Furthermore, PFEP offers accurate, and also a wide range of information about the parts, which is highlighted with the following example: As most companies use MRP to manage their purchased parts, they end up storing 50 % air in their parts racks according to their system. PFEP, on the other hand offers precise information of the part in each stage in the supply chain. (Bartholomew 2015.) The latter one which, essentially leads to leaner operations as with MRP.

Moreover, PFEP also serves a foundation for Kaizen, the continuous improvement practices, within the material-handling systems of the plant. (Bartholomew 2015.) This relates to lean in an unavoidable way, as learned previously in this chapter. For instance, with PFEP implementation, some companies have experienced long-term improvements, such as reduced days of inventory, increased productivity and boosted on-time delivery practices. (Bartholomew 2015). In addition to these reasons, PFEP can be seen having a connection to lean also since, PFEP does not create value as itself, but it is however an essential element in supporting value-creating activities with providing needed, accurate and timely information in an easy-access way. (Harris etc. 2003, 21.)

4 CASE VALMET AUTOMOTIVE

This part of the paper is dedicated for describing VA as a company, in the perspective of the PFEP topic. In relation to the chapters two and three, it is an objective now to link those ideas presented there, to the details within the VA. The idea is then to create a connection between the theory discussed, and practical research and work done. The latter one which is shortly introduced in the end of this chapter, and further discussed in chapter five where the results and analysis of the paper are given attention.

In the following, the structure of the internal logistics within VA is first introduced. In particular, the one of the picking process is in focus. After this, the implementations of lean methods and philosophy taken in place throughout the processes of internal logistics, are then presented. The aim here is to connect the internal logistics of VA with the theory presented in chapter two, and especially to argument each lean method discussed in chapter three with the way VA operates its internal logistics.

The chapter continues then to depict the current development methods in use of VA internal logistics department, which are also connected to the PFEP in creation. First of all, the development method based on part information is given attention. After this, the focus continues towards work studies and balancing, which are some fundamental methods used within VA. Finally, the PFEP in previous use of the VA internal logistics department is described with a surface level perspective. As a whole, this part is closely related to theory and literature as the previous chapters. It is however essential to have it in the case section and not in the theory part, as it essentially describes the VA in particular, not for example PFEP or the data set in it, in general.

Chapter is ended then with presenting some details of the new PFEP in creation during this thesis project. In essence, the requirements and objectives are further explained from the introduction part. Moreover, the process of execution is also elaborated on, in order to give valid insight in relation to the results and analysis of the project presented next in chapter five.

In addition to the data collection methods already explained for the distinctive parts, other information in this chapter is based on the interview held with both the management level and shop floor personnel of VA internal logistics, in particular the development team. Some parts are given attention, especially with a written interview, created for the internal logistics development team of VA, in the responsibility of Kalle Karvanen and Juhani

Kerminen. The interview base, and questions created 20.3.2018 can be seen from Appendix 1, while the answers, received 5.4.2018 are given source markings within the text, to either Karvanen or Kerminen depending on the question.

To be yet mentioned, as an international company, English is the official language of VA. However, the internal logistics department in Uusikaupunki plant operates mainly in Finnish within the plant. Therefore, the interview held and attached to this paper, was also adjusted to the supportive Finnish language.

4.1 Internal Logistics

Regarding the case of VA on hand, it is necessary to focus on the internal logistics view in specific. In this chapter, it is of benefit to keep in mind the internal logistics theory presented earlier, in chapter two, as the processes of VA essentially follow the pattern with some distinctive specifications. These matters of internal logistics and in particular, of picking process are then introduced now. This, in order to create a complete view on the case.

In addition, the internal logistics of VA includes the use of several lean methods, which links are introduced in this part as well. Alongside this, it is necessary to keep in mind the ideas of chapter three where the methods, presented here, are discussed more in depth. All this is essential to be discussed, before focusing on the practical thesis work made in this project.

Structure of Internal Logistics

As many processes within VA, the internal logistics consists of multiple complex set of processes. This is often the case with large companies and plants, especially the ones related of automotive manufacturing. The reason for this lay on the fact, that cars include thousands of parts, from smaller ones to bigger ones, which all require a specific type of processing.

In particular, VA has also faced changes in its manufacturing operations quite often during the last few years, which in essence affects the processes as well, especially when it comes to the internal logistics. Moreover, VA continuously attempts to improve its internal logistics processes, which then creates even more changes.

Essentially, VA has considered different strategies for different parts. In detail, all the components within the VA operations end their way either to the assembly or the welding shop. The path to get there is then planned separately for each part relating to the nature and the use of the part. The most common process is presented in Figure 7.

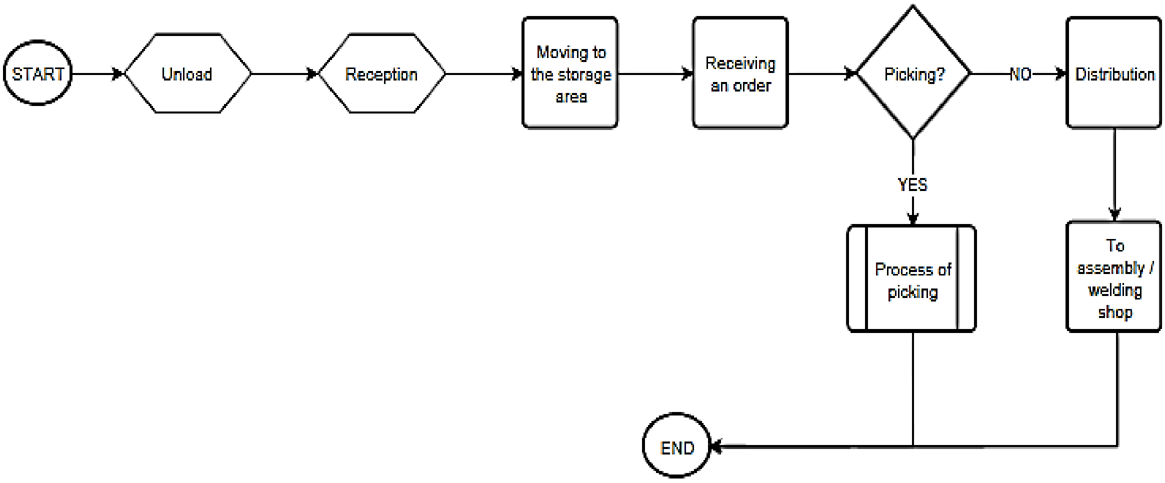


Figure 7. The common process of VA internal logistics.

First of all, the unloading area is chosen from three different ones within the plant and several others related to the external storages around the southern Finland area. The unloading and reception area are most usually the same, but they must be treated as two different functions. While the unloading consists of the physical move of the products, during the reception the incoming loads are being checked, whether if they consist of correct amounts and of correct components. Moreover, the loads are being taped with a code, matching the one coming from the supplier. This, in order to check the products to the systems of the plant. After this, the loads are moved inside to wait for the distribution to the storaging area.

The distribution is made with trucks, which operate according to the IS in use in the plant. In practice, the system names an storage area that the particular items must be moved to throughout the plant.

The storaging area can vary, in addition to the many external storages, from multiple ones within the plant as well. These are automatic, shelve or floor storages, from which the first-mentioned ones have a more distinctive process, while the last two are more related to each other.

One distinctive feature with the internal logistics process of VA, is the additional storaging types. First type is constructed for the parts which are planned and synchronized for particular cars. Another one is set for those parts that require especial attention in handling and must be documented with focus, such as the keys for the vehicle.

The process then is continued with the use of IS. In detail, the assembly or the welding shop places orders which then are received by different types of trucks (forklift, carriage or transit) depending on the components and locations. The parts are then distributed to the picking areas, which after this continue their path further according to the picking process presented next, or directly for use of the assembly or welding shop.

Picking Process

From the process described above, the picking one is in particular focus next. This, because the created PFEP in this thesis project is focused only on this part of the VA internal logistics. In order to give more insight, Figure 8. presents the picking process.

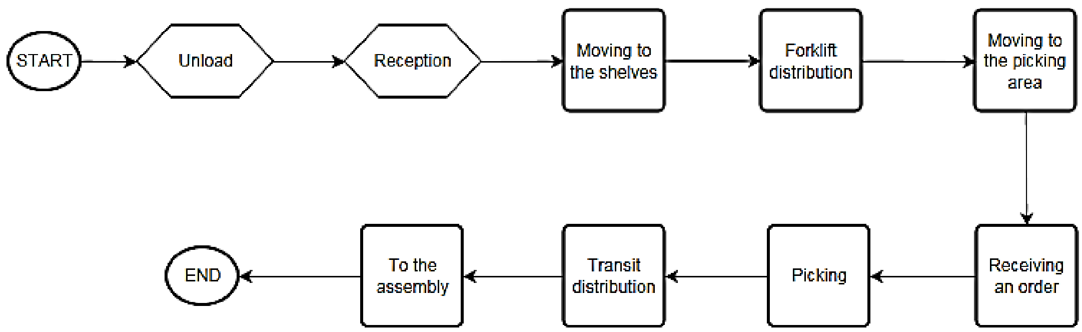


Figure 8. The picking process of VA.

In detail, all of those items included in the picking process, have one common unloading and receiving area. From there, they are moved to either shelve or the floor storage areas.

There are other picking processes as well within the operations of VA, but they are however treated as separate kind of processes. These are for example the ones in external storages, automatic storage, and additional picking storage. Related to the case in attention, these independentent picking processes are left outside of the focus.

From the storaging area, the components are then moved and placed to identified picking areas, where the picking can start once an order is placed from the assembly. The ready picked components are, after this, distributed directly to the assembly.

In essence, VA has divided picking components into two groups: large and small picking. The differentiation of the two is mainly based on the size and the requirement of different trucks for distribution. Moreover, while small picking is accomplished with the help of speech control, large picking is planned to be imporved towards it as well in the nearby future, if proven effective for it.

Inspite of these differences, both pickings include more or less similar types of parts, which are synchorinized or repacked parts, in addition to parts which are picked based on part numbers requiring certain features. Parts to be synchronized, as discussed previously, stand for how JIS takes place in the VA manufacturing, which was explained in chapter three with detail. Repacked components on the other hand are the most simple ones, as the functions with them only include moving of the parts from original packages to the picking carts or similar ones which suit the assemply line better. Items which are to be picked based on part numbers can relate to different colours of same parts, for example. This gives an indication for JIT production which was further elaborated on in chapter three.

On a side note, those components requiring picking are perhaps the minority from all parts revolving in the VA plant. In detail, only the components of assembly can be picked, if necessary, in the case of VA. Moreover, synchronized parts, as explained previously, are the only actual group which are all meant to be picked. All in all, having components requiring picking is not beneficial for the company, since they add steps to the process. In fact, it is an objective of several projects of VA, to minimize the picking components in the future, in order to increase the efficiency within the operations (Personal Information. Kalle Karvanen 5.4.2018).

Implementations of Lean

In relation to the internal logistics of VA, there are several elements of lean that regard to the way VA operates. As JIT and JIS were discussed previously in this chapter, the rest of the theory and lean methods presented in chapter three, are now to be linked to practical examples regarding the VA case, and PFEP thesis project in attention.

First of all, it is to be announced, VA has an continuous attempt for introducing ideas of lean manufacturing and material management with implementing supportive methods. In fact, the development measures towards leaner operations is a constant objective in several different projects.

In essence, VA gives a basis for its internal logistics operations with six sigma methodology. This, for example meaning the control of the products are attempted to be done in a way, that would not create any excess processes or use of space. (Personal Information. Juhani Kerminen 5.4.2018.)

To put additional focus on development, the internal logistics of VA has continuos improvement initiatives in place, where employees can suggest both incremental and radical changes for the benefit of the operations. This is then supported with different compensations.

When it comes to efficiency, its indicator is created with specific KPIs, examples of which presented in the end of chapter two, and Overall Equipment Effectiveness (OEE) values that VA has identified in prior. Those, give then reason for areas and objects of improvement which are this way supported with arguments. (Personal Information. Juhani Kerminen 5.4.2018.)

In short, OEE relates to lean TPM, presented in the beginning of chapter four. Lean TPM can be also identified as a lean manufacturing tool, in one perspective, which in detail, improves the reliability and efficiencies of the equipments and machines under utilization in the organization with a team. The ultimate objective is to improve processes and equipments continuosly by improving OEE. (Lean Manufacturing Tools 2018g.)

OEE can be then described as a metric for TPM which is gained through measuring the six big losses. These are defined as breakdowns, setup and adjustment losses, idling and minor stoppages, reduced speed, defects and rework, and start-up losses. (Lean Manufacturing Tools 2018g.) In practice, OEE identifies the percentage of planned production time which is in truth, productive with supporting TPM initiatives.

In addition to the mentioned ones, some other lean methods are presented in the end of the following subchapter. This because they relate to the new PFEP in creation. They can however still be seen as lean implementations of VA since there are projects and objectives within them, put in place in order to be achieved. This thesis project acts as a good example in this perpective.

4.2 Current Development Methods of Internal Logistics

The focus of the development measures of the internal logistics department of VA, is at the moment related to constructing an efficiency indicator of h / car, which essentially is argumented for, with the new PFEP in creation.

As presented in the introduction chapter of this paper, during the spring of 2018, VA started manufacturing two different Mercedes models in parallel. Naturally, these kinds of changes create its own challenges which often regard to the aspects of optimization (Personal Information. Kalle Karvanen 5.4.2018). In particular, the relation between space and efficiency is in question (Personal Information. Kalle Karvanen 5.4.2018).

The changes affect the organization as well. While before, the development of the internal logistics was centralized for one bigger team, it is now sectioned in many smaller teams which are specialized in different areas. One team who was particularly important for this paper, was the team of work studies and measurement, for example.

The new organization constructed for these new changes and objectives, is however seen to benefit the company as a whole. In essence, it is thought to enable the boost within the operations in multiple different areas at the same time, which is an improvement from previous. (Personal Information. Kalle Karvanen 5.4.2018.)

In relation to the future challenges, one of them regards to the overlapping of projects, especially when it comes to the biggest ones. Moreover, to find skilled and competent personnel for whom the work can be delegated to, is another obstacle. The department believes however that with the new organization most of these challenges, amongst others can be tackled. (Personal Information. Kalle Karvanen 5.4.2018.)

In the following, as explained in the beginning of this chapter, the current development methods in use of VA internal logistics department, are now explained, this in connection to the PFEP in creation. All in all, methods given attention are part information, work studies and balancing, in addition to the PFEP had in use previously in the VA internal logistics department. From these, the last one is discussed with a surface level perspective, while the other two relate closely to which the new PFEP information is created from.

4.2.1 Part Information

The first method of development used within the internal logistics department of VA, is part information. Regarding the picking process, this information is, especially to plan and develop the picking areas or routes. Moreover, they can be taken advantage of while planning which functions the parts affect in the operations. (Personal Information. Kalle Karvanen 5.4.2018.)

The challenge here is often related to the accuracy of the part information (Personal Information. Kalle Karvanen 5.4.2018). In a way, this process can be further improved with PFEP implementation, since in essence it arguments for accurate information, also in relation to parts. This kind of development then could lead to better optimization of storages, and to more efficient operations (Personal Information. Kalle Karvanen 5.4.2018).

Moreover, part information related to the forecast demand of specific period is used as one information base used for the PFEP created in this thesis project. This then would further emphasize the importance of accurate of part information, especially if PFEP is meant to have of the most use in the future.

4.2.2 Work Studies and Balancing

Another method used for development purposes in relation to the VA case, is the one related to work studies and balancing. These are both ideas fundamentally inserted in the operation ways of VA. In the following, related ideas are presented in appropriate ways.

The essence of work studies lay on the aim of improving the efficiency of the operations. Objectives are then related to investigating the best practices for the work in perfomed. In addition, another target is to find the best possible circumstances for the work (Uusi-Rauva etc. 2005, 490).

Work studies also have multiple perspectives that vary regarding the objectives taken. The aspects in question, are related to economical, technological and employee ones. (Teknologiateollisuus ry 2011, 6.) In relation to this paper, and in particular to the case in discussion, the economical and technological perspective are in especial attention.

These, in the focus to the expense cutting and new processes developing actions (Teknologiateollisuus ry 2011, 6).

Moreover, work studies can be divided into four different areas, which are methods studies, the institutionalization of the work, occupational instruction and guidance, and work measurement (Uusi-Rauva etc. 2005, 490).

Methods studies essentially relate to the systematic development of the work which aims to the efficient, economical and safe way of working. The second one, institutionalization of work relates then to ensuring that all work, made by different employees is made with as efficient ways. On the other hand, occupational instruction and guidance ensures that all employees are on top of the best, most efficient and safe methods for the work. (Teknologiateollisuus ry 2011, 6-7.)

Work Measurement

While the already mentioned areas relate closely to the way VA operates and develops its operations also within the internal logistics, the last area of work studies, work measurement has a connection directly to the thesis and case on hand. Therefore, this area is discussed in the following with a more focus.

Work measurement in detail aims to find out the time that is taken by the employee to do the work. This is done with standard ways of work measurement, as mentioned later in this subchapter. It is also an objective to do the research in ordinary circumstances. Furthermore, it is of benefit if the work is remeasured multiple times, in order to ensure the accuracy of the time taken with taking an average from the measurements. This, because same work can be done with different durations at different times. As a result, an average time is drawn which indicates the duration that the task requires from a professional employee. This can be further applied for example, to the investigation of the lead time of operations. (Vartiainen 1994, 125.)

There are also different stages to work measurement. First, the research must be informed. Then it is essential, that the work methods are identified, and then the work is sectioned with descriptions of each. It is also necessary to measure durations at different times, after which the end result can be calculated with an average. As a last step, the results must be presented and documented as needed. (Teknologiateollisuus ry 2011, 25).

In detail, work measurement research can be conducted in different ways. Some common ways are experimental research, clock time research in division to normal time and time usage research, motion time research, time calculations research and standard time systems. (Teknologiateollisuus ry 2011, 24.) In relation, work measurement methods used by VA were researched further during the process. This is not however covered in this paper for confidentiality reasons.

The connection between Work Measurement and Lean

As described in the previous, chapter three, lean is based on developing those processes of the operations which create value to the customer. This, while eliminating all waste s within it. The objective is then to construct a flow where products move without a stop in the value chain. Thus, work methods and processes are both being standardized, and production is evened. (Teknologiateollisuus ry 2011, 21.)

In the same chapter, Kaizen, was presented as one of the lean methods depicting continuous improvement. This essentially, is something that also work studies and work measurement methods can be connected to, as they can lead us towards a leaner way of operating. (Teknologiateollisuus ry 2011, 22.) One of the most important reasons for this is, that the flow creation throughout the production requires time related information from the manufacturing processes. This is often indicated with lead time, which can be research with work measurement methods, as explained earlier in this chapter. (Teknologiateollisuus ry 2011, 21.) This is how, work measurement is connected to kaizen, and eventually, to lean operations.

4.2.3 PFEP

VA has aimed to put together a complete PFEP to be used in the internal logistics development. However, for the moment, there is no PFEP in use, because of some issues risen.

The PFEP related to the operations was constructed in 2015, which then faced the end of its cycle life a year later, in 2016 (Personal Information. Kalle Karvanen 5.4.2018). This was due to information, and on the other hand also, to organization related transformations. For the time it was in use however, it was efficient and enabled, for example the simulation of different changes, such as packaging or function related ones (Personal Information. Kalle Karvanen 5.4.2018).

4.3 New PFEP Tool

In the following, the creation of new PFEP tool is described based on the requirements and objectives set for it, some of which are already been presented in the introduction and previous chapters of this paper. Moreover, few connections to lean implementations and this way relating to the complete objectives of VA, are also given attention. After this, the process of execution is also introduced, before the results and analysis are put in focus next, in chapter five.

Requirements and Objectives

The requirements of the new PFEP are essentially related to the data retrieval, which are based on the forecast demand and work measurement results of VA, as revealed in the introduction. These are not however presented in detail here, in relation to confidentiality matters.

With these required data sources, the essential objective of the new PFEP, is to enable development practices in the internal logistics department of VA. Essentially, for this project the data collection of Mercedes GLC parts within the picking process are set on focus.

The aim is then, to construct a functioning and easily updatable PFEP development tool for the picking process while making research on what kind of data is needed for such, and how to access it. In practice, after constructing the PFEP, the information wanted to be drawn as a first step, is to have a complete time of work for each part (Personal Information. Juhani Kerminen 5.4.2018).

Another target is to create the tool to act as a complete PFEP base. This can be then, in the future, further improved to reach beyond picking process towards the rest of the internal logistic processes, and then ultimately forward the entire tool to a more sustainable, automatized format.

In essence, the PFEP after this project, should attempt to be a basis for the research made, in a way that it can be of functional use with updating only some necessary base information (Personal Information. Juhani Kerminen 5.4.2018).

New PFEP empowering Lean Operations of VA

As for the lean implementations which are aimed to be achieved with the new PFEP, several are in focus. Thus, this section is a continuation of the previous subchapter related to the connection between chapter three and the actual lean regarding actions taken by VA.

First of all, PFEP affects as giving reason in measuring, following and later on, also simulating the results of the operations with having them defined. For example, this leads then to a complete view on the Total Cost of Ownership (TCO) of the operations. (Personal Information. Juhani Kerminen 5.4.2018.)

The impact of TCO regards to the fact, that it gives a complete view on the costs of purchasing put in place in the operations. This way, it considers the costs of the purchase through its entire life cycle. In essence, the idea is not to define the expenses with every detail included. Instead, the objective of TCO is to bring out the most essential expense factors, especially those of long-term purchases with high monetary value. Thus, it enables more effective decision-making process, for instance. (Logistiikanmaailma 2018d.)

For these reasons, it is clear that TCO essentially is an important element leading to a lean organization. By having TCO model as a base for the operations, lean methods have a more efficient outcome, which can be indicated with additional cost savings, for example. This applies also to the case of VA, especially with the new PFEP as presented.

In addition, as VA bases its operations to six sigma methodology, it also avoids all kinds of wasteful processes and work, which is the essence of lean as chapter three also discusses. In relation, PFEP is attempted to have linked with other production models and areas of business, in the future. This meaning, that eventually, the PFEP is not only meant to be a tool to develop internal logistics operations, but also to have it as a complete base to indicate expenses in relation to the complete TCO of the company. (Personal Information. Juhani Kerminen 5.4.2018.)

Process of Execution

The process of execution regarding the PFEP was at the same time complex and simple. What made the process complex, related mainly to the abstract nature of the topic. In detail, the path includes every step from introduction to the internal logistics processes, and to the drawing ideas for further improvement of PFEP, as can be seen in Figure 9.

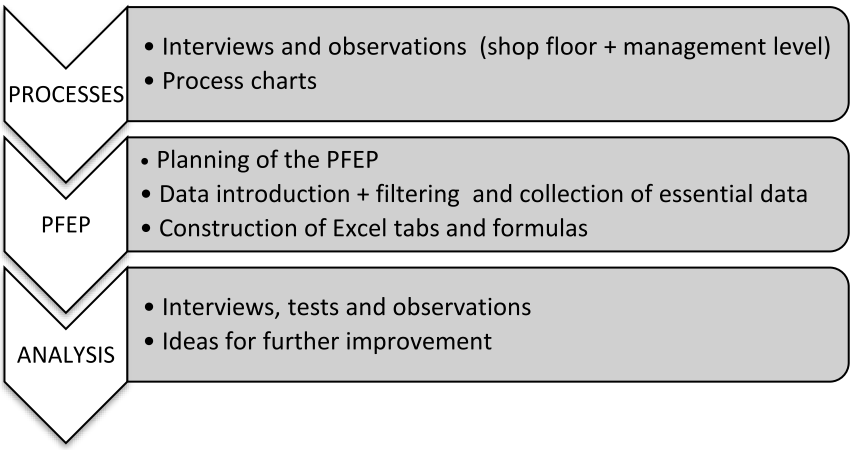


Figure 9. The process of execution in relation to the new PFEP created.

5 RESULTS AND ANALYSIS

The results of the practical work done for this paper are next presented and analysed. For this chapter, the ideas discussed prior, in the case section should be in particular attention, in order to achieve a complete understanding.

In addition to the work done and presented so far in the previous chapters, the practical part of this thesis project culminates to the construction of the actual PFEP. The format chosen here is excel as a first step, since it offers wanted flexibility and easy access.

There are many pros in using excel in the early phase of building the platform. First of all, the PFEP is better to have first fully constructed and formulated before it can be transferred to a more sustainable format. This is particularly significant in the case of VA, since the company has a variety of complex processes within its operations, and as PFEP is wanted to be as accurate as possible, the changes to the platform are daily in this step. Thus, excel offers a low obstacle for changes and error-corrections.

Moreover, during this thesis project it was seen of most benefit to start with a format and program which is already familiar to the student speaking, especially because of the time limitations set for the project. This way, all the time available, was directed towards the actual work, and not to the learning process required to get familiar with a new program, instead.

As mentioned in the beginning of chapter four, English is the official language of VA. Despite this, the operations within Uusikaupunki plant are mainly reached in Finnish. Thus, the written work and PFEP done are also adjusted to the supportive Finnish language. Some ideas presented in this chapter are now however translated to English, in particular for this thesis on hand, to emphasize the most crucial elements of the project.

All in all, in the following, the work done is introduced in detail. This is then supported with illustrating screenshots taken from the actual PFEP excel made with an appropriate perspective, respecting confidentiality details.

The Finished PFEP

First of all, as it has been established previously, the data used in this PFEP is related to the forecast demand, providing needed part information and the demand of a specific period of time in attention. Another data source is related to the work measurement results. These are not however elaborated on further here for confidentiality reasons.

All in all, with this data base, one great Excel document was created, including six different tabs, each of them which have a purpose of its own, as will be presented next.

- ✓ Linear process charts
- ✓ Forecast demand base
- ✓ PFEP conclusion tab
- ✓ **Picking calculations** (picking)
  - ✓ Time values
  - ✓ Change indicator

The linear process charts relate to the process investigation of the internal logistics department presented already in the case section of chapter four. Adapted to the excel format, the processes can be now easily checked if needed, especially when figuring causalities for new calculations.

As for the forecast demand base, it is there for easy access to filtering, especially in relation to the tab creation for other processes, since picking is now completed. The data in this tab acts as a base, meaning new, current data can be updated to here from the ERP system when wanted, which then updates the formulas in the other tabs automatically.

The PFEP conclusion tab, next gives attention to the h / part calculations based on each particular process investigated. In essence, this tab does not include any other columns that are not of use in this point. This, to only conclude the result information drawn from the other tabs yet to be presented. For now, the h / part is completed for the picking process according to the objectives, as can be seen from Picture 10. below. This formula is further explained later on in this chapter.

PART NUMBER	PART NAME	PICKING
A	AAA	10,250
B	BBB	10,250
C	CCC	0,658
D	DDD	0,023
E	EEE	0,372
F	FFF	6,547

Picture 9. An illustration of the PFEP conclusion tab.

The following tab presents the picking calculations for h / part in this case, as one objective of the paper. Essentially, the objective was to eliminate every information column that was of no use for the picking process regarding the parts of Mercedes GLC. For confidentiality reasons, these steps are left outside the the published version of this paper.

The content of this tab can be however explained shortly. The first two columns relate to the identification of the part, while the next three explain the locations where each process takes part. This gives valuable information about the handling of the part: different locations for storaging and unloading often relate to different work measurement times for example, which has a major impact in this case. The last three columns are then the ones that are in particular attention in this project. One of them is related to batch labels, which essentially represent as one of the most important identificators for picking parts in VA. Every picking part has a certain label, and each label consist of a certain group of picking parts. The essence of a batch label is mainly system related, and is not in fact seen on the shop floor. Thus, they are used for more efficient picking organization and operation.

The explanation of the remaining tabs (including details for values drawn from work measurement studies) are left outside the published version of this paper for confidentiality reasons. In relation the specific calculation methods and formulas for the resulted h / part were also further investigated during the thesis process, but left unexplained in this context for the same reason.

Further Analysis of the PFEP created

In relation to this project, full analysis is provided to VA. In the perspective of this publicly published paper however, only some general matters of analysis can be discussed, while most is left unpresented due to confidentiality.

When analyzing the finished PFEP, and comparing it with the old, outdatet PFEP, the benefits are obvious. New PFEP is now fully updatable and can be even worked with regarding the picking process as it is. Current data can be implemented to the Excel created and the formulas are constructed with a sustainability aspect kept in mind.

The only manual work relating to this PFEP is now the values of work measurement. In the case of new processes which then would require new work studies and possibly new values, they must be inserted to the Excel manually. It was an attempt to create a linkage between the file of work studies with the PFEP, but it was not seen sustainable, and thus it was decided to keep this step manual for now.

The actual h / part constructed with the PFEP is then consulted regarding sensible values in a general level. This can be then used in the case of VA to indicate the perormance of the operations and to assess the effects of changes, for example. In addition, change requirements sent from Daimler, can be issued with reliable arguments got from the PFEP. Also, future changes can be simulated better with this tool. (Personal Information. Juhani Kerminen 5.4.2018.)

All in all, as explaind throughout the paper, this PFEP created acts essentially as a development tool. It empowers leaner operations and more efficient process development. As one example the PFEP describes in which parts most of the resources of the plant lay, especially in the perspective of expense. These can be then optimized as wanted, if seen unreasonable.

Thus, the created PFEP can be now used as a development tool for the picking process. It can be also implemented further to concern other processes of internal logistics, and even to processes of VA in a more general level if wanted, as well. The simple, accessible basis is already created for these actions, with the picking process acting as an initial example. As wanted, a way to automatized format is also presented in the conclusion part, later in this paper.

Practical Challenges with the PFEP

Some practical and possible challenges are next drawn in this part of the analysis. Here, a discussion in the form of an interview, as presented in Appendix 1, made with the internal logistics development team of VA, is taken adventage of, in particular.

One major challenge is seen to be the possible false interpretation of the PFEP tool. Another issue could be created if the tool is taken apart in relation to some particular sections, which then result the PFEP to give faulty outcome. This can then affect as decreasing efficiency and possibly increasing expense factors, when data is forwarded with false basis. In order to keep this misuse from happening, the appropriate training must be put in use for those who will be using the PFEP. (Personal Information. Juhani Kerminen 5.4.2018.)

6 CONCLUSIONS

To conclude, the starting point of this project was that VA had an outdated PFEP, which was already in the end of its life cycle. In this basis, research regarding PFEP was conducted: the theory base was found to link PFEP to the ideas of logistics and lean. After this, the case of VA was given more attention, in order to provide a framework in which the creation of the new PFEP could be inserted. Later on, the work made was presented and further analysed.

Key findings here are related to the complexity of VA internal logistics. In a way, this was a bottleneck in the creation of PFEP: the processes must be clear enough before preparing for this work. A solution provided during this project, was offered via process charts illustrated for each process related to the internal logistics of the plant. In this basis, PFEP is created now for the picking process, and it can be improved this way to other processes as well. Moreover, the importance of certain measures and values are particularly emphasized with the picking process as taken in consideration in this work as well. The formulas created for h / part thus support these ideas and offer valuable information to the PFEP.

The most critical challenges related to this thesis project were also concluded and elaborated on during the process. This is not however covered in this paper for confidentiality reasons.

In relation to concluding ideas, some suggestions for further improvement are offered as an addition outcome of this thesis project. This relating to both the development of PFEP created so far, and the way VA performs its operations as well.

Suggestions for further improvement

While the creation of PFEP started here with illustrating and clarifying the processes of VA internal logistics, the first suggestion relates to this. In order to keep all the development work linear, it is important to have the processes clarified for all the members of the organization, and update those when developed further. One idea could be to introduce a communicative intranet, or similar, where information regarding this is communicated in real time. This could be then implemented to other issues necessary to have them updated constantly. As a result, this would enable the development of PFEP, and also reduce the amount of calls, emails and meetings in a daily basis regarding other work as well. This should be of particular attention as an suggestion. Especially when, as witnessed VA bases its operations to constinuous development.

Some of the other suggested improvements related to this section, for example regarding the used data, is also offered in the end of the PFEP project. Those suggestions are not however covered in this paper for confidentiality reasons.

One specific area of improvement to be yet mentioned, relates to labels and designations revolving in the VA plant. In detail, it would be of most benefit, if those would be linked to each other. At the moment, it is not obvious which label and work measurement regard to which part in each situation. To have linear naming system would make the development work less of a challenge, especially now when the internal logistics is facing the production of two car models in parallel, which seems to be the operating model in the future as well. In the case of PFEP, the collection and linking the data would be made more reachable with this suggestion, as well.

Another idea is also to have the PFEP fully updatable, which is at the moment already achieved, apart for the work measurement values which were reasoned for previously in this paper. To have all this data automatically updated would be another target to aim for.

The Excel created so far can be further developed with different macros, and essentially forward to a more sustainable, automatized format, for example to Microsoft Access, which is already in the consideration of VA internal logistics. An ultimate goal is to have the PFEP Excel created now as a data base, where different departments, not only internal logistics but also others, would add the data relating to the. This would be then used by Access, which would offer a way to do the development work in an organized and sensible way with the data being as accurate as possible.

REFERENCES

AllAboutLean 2017. Just in Sequence Part 1 – What Is It? Lean tools. Referred 3.5.2018. https://www.allaboutlean.com/just-in-sequence-definition/

Asiakastieto 2016. Financial Data. Valmet Automotive Oy. Referred 12.4.2018. https://www.asiakastieto.fi/yritykset/fi/valmet-automotive-oy/01439912/taloustiedot

Bartholomew, D. 2015. Why a Plan For Every Part is Essential To Lean Transformations. Lean Enterprise Institute. Referred 7.5.2018. https://www.lean.org/common/display/?o=2951

Bhose, C. 2017. Valmet Automotive rikkoo vanhat ennätykset. Kauppalehti. Referred 5.4.2018. https://m.kauppalehti.fi/uutiset/uutinen/KswfNJQe

Chen, C. Tune-up Your Factory's ERP using Plan for Every Part (PFEP). . LeanDNA Blog. Referred 7.5.2018. https://www.leandna.com/blog/tuneup-erp-plan-every-part-pfep/

Conrads, T. & Rooks, R. 2016. Turbo Flow: Using Plan for Every Part (PFEP) to Turbo Charge Your Supply Chain. New York: CRC Press.

Flinchbaugh, J. 2005. Lean Material Management. Facilities Management. Material Handling & Logistics. Referred 3.5.2018. www.mhlnews.com/facilities-management/lean-material-management

Harris, R.; Harris, C. & Wilson E. 2003. Making Materials Flow: a lean material-handling guide for operations, production control and engineering professionals. Cambridge: Lean Enterprise Institute.

Harris, R. & Harris, C. 2013. Capitalizing on Lean Production Systems to Win New Business: Creating a Lean and Profitable New Product Portfolio. New York: CRC Press.

Hokkanen, S. & Virtanen, S. 2013. Varastonhoitajan käsikirja. 2nd Edition. Kangasniemi: Sho Business Development.

Intolog. Varaston tuottavuuteen voi vaikutaa hyvällä suunnittelulla. Referred 18.4.2018. https://www.intolog.fi/fi/ratkaisut+ja+referenssit/varastointi/tuottavan+varaston+suunnittelu/ Original source marked as: Aminoff, A.; Hyppönen, R. & Kettunen, O. 2004. Varastotoiminnan benchmarking - yleiset tulokset.

Islam, D.; Meier, J.; Aditjandra, P.; Zunder, T. & Pace, G. 2012. Logistics and Supply Chain Management. Referred 7.2.2018. Downloaded from Elsevier.

Kankare, M. 2018. 150000 Mersun valmistus vaatii kirurgintarkkaa datan hallintaa. Talouselämä. Referred 16.4.2018. https://www.talouselama.fi/uutiset/150-000-mersun-valmistus-vaatii-kirurgintarkkaa-datan-hallintaa/325541a9-1bd9-3a3f-91d1-cde1ba98b9a3

Karhunen, J.; Pouri, R. & Santala, J. 2004. Kuljetukset ja varastointi: järjestelmät, kalusto ja toimintaperiaatteet. 2nd Edition. Helsinki: Suomen Logistiikkayhdistys.

Karjalainen, J.; Blomqvist, M. & Suolanen, O. 2001. Kehittyvä toiminnanohjaus. Helsinki: Metalliteollisuuden kustannus 2001.

Lahtinen, H. & Pulli, J. 2012. Logistiikkakeskuksen kehittäjän käsikirja. Referred 20.4.2018. Downloaded from: http://www.eslogc.fi/fi/tuloskirja.html

Lean Manufacturing tools a. Lean Thinking, Lean Principles. Referred 26.4.2018. http://leanmanufacturingtools.org/39/lean-thinking-lean-principles/

Lean Manufacturing tools b. Lean Manufacturing Tools. Lean Tools. Referred 3.5.2018. http://leanmanufacturingtools.org/

Lean Manufacturing tools c. What is Kaizen? Referred 3.5.2018. http://leanmanufacturingtools.org/621/what-is-kaizen/

Lean Manufacturing tools d. The Seven Wastes, 7 Mudas. Referred 3.5.2018. http://leanmanufacturingtools.org/77/the-seven-wastes-7-mudas/

Lean Manufacturing tools e. Muda Mura and Muri, Lean Manufacturing Wastes. Referred 3.5.2018. http://leanmanufacturingtools.org/71/muda-mura-and-muri-lean-manufacturing-wastes/

Lean Manufacturing tools f. Just in Time (JIT) Production. Referred 3.5.2018. http://leanmanufacturingtools.org/just-in-time-jit-production/

Lean Manufacturing tools g. Total Productive Maintenance; Implementing a TPM Program. Referred 4.5.2018. http://leanmanufacturingtools.org/421/total-productive-maintenance/

LeanPro. Material Flow Strategy Implementation Plan For Every Part (PFEP). Referred 7.5.2018. www.leanpro.org/en/implementation.html

Lehtelä, S. 2018. Uudenkaupungin autotehtaalle 1000 uutta työntekijää tänä vuonna. Yle Uutiset. Referred 5.4.2018. https://yle.fi/uutiset/3-10072747

Liikenne- ja viestintäministeriö 2009. Logistiikkaselvitys. Referred 10.4.2018. http://urn.fi/URN:ISBN:978-952-243-030-4

Liikenne- ja viestintäministeriö 2012. Logistiikkaselvitys. Referred 18.4.2018. http://urn.fi/URN:ISBN:978-952-243-327-5

Logistiikanmaailma a. Toiminnanohjausjärjestelmä. Referred 17.4.2018. www.logistiikanmaailma.fi/logistiikka/ohjausjarjestelmat/toiminnanohjausjarjestelma/

Logistiikanmaailma b. Ohjausjärjestelmät. Referred 17.4.2018. www.logistiikanmaailma.fi/logistiikka/ohjausjarjestelmat/

Logistiikanmaailma c. Varastonhallintajärjestelmät. Referred 17.4.2018. www.logistiikanmaailma.fi/logistiikka/ohjausjarjestelmat/varastonhallintajarjestelmat/

Logistiikanmaailma d. Kokonaiskustannusajattelu. Referred 21.4.2018. www.logistiikanmaailma.fi/osto-ja-myynti/hankintatoimi-ja-ostotoiminta/kokonaiskustannusajattelu/

McCarthy, D. & Rich, N. 2004. Lean TPM: a blueprint for change. Amsterdam; Oxford: Elsevier Butterworth Heinemann.

Ministry of Transport and Communication 2009. Finland State of Logistics. Referred 10.4.2018. http://urn.fi/URN:ISBN:978-952-243-050-2

Nikula, P. 2017. Uudessakaupungissa on pian Suomen suurin tehdas – Koskaan ei ole mennyt näin hyvin. Kauppalehti. Referred 5.4.2018. https://m.kauppalehti.fi/uutiset/uudessakaupungissa-on-pian-suomen-suurin-tehdas---koskaan-ei-ole-mennyt-nain-hyvin/sF9xTUAM

Ostdick, N. 2016. Why Companies Should Plan For Every Part. Flexis. Referred 7.5.2018. https://blog.flexis.com/why-companies-should-plan-for-every-part

Pentas 2016. ‘Just in sequence’ takes ‘just in time’ a step further. Referred 4.5.2018. www.pentasmoulding.com/just-in-sequence-takes-just-in-time-a-step-further/

Protzman, C.; Whiton, F.; Kerpchar, J.; Lewandowski, C.; Stenberg, S. & Grounds, P. 2016. The Lean Practioner’s Fiel Book: Proven, Practical, Profitable and Powerful Techniques for Making Lean Really Work. New York: CRC Press.

Raunio, H. 2016. Valmet Automotivella jo 600 robottia Uudessakaupungissa – silti ihmistyövoimankin kysyntä yhä vain kasvaa. Tekniikka & Talous. Referred 5.4.2018.

https://www.tekniikkatalous.fi/talous_uutiset/yritykset/valmet-automotivella-jo-600-robottia-uudessakaupungissa-silti-ihmistyovoimankin-kysynta-yha-vain-kasvaa-6605662

Richards, G. & Grinsted, S. 2016. The Logistics and Supply Chain Tool Kit: over 100 tools and guides for supply chain, transport, warehousing and inventory management. 2nd Edition. London; Philadelphia: Kogan Page 2016.

Sakki, J. 2001. Tilaus-toimitusketjun hallinta: logistinen b to b -prosessi. 5th Edition. Espoo: Jouni Sakki Oy.

Six Sigma a. Lean. Referred 24.4.2018. www.sixsigma.fi/fi/lean/

Six Sigma b. Six Sigma. Referred 4.5.2018. www.sixsigma.fi/fi/six-sigma/

Teknologiateollisuus Ry 2011. Työntutkimuksen käsitteitä, menettelytapoja ja käyttökohteita. Juva: WS Bookwell Oy.

Uusi-Rauva, E.; Haverila, M.; Kouri, I. & Miettinen, A. 2005. Teollisuustalous. 5th Edition. Ylöjärvi: Infacs johtamistekniikka 2005.

Valmet Automotive 2015. VA Company Brochure. Referred 5.4.2018. Downloaded from: www.valmet-automotive.com/automotive/cms.nsf/pages/4CCEB3826788CCCCC225799D0046364C?opendocument

Valmet Automotive 2016. Autotehtaan sisäinen logistiikka osaksi Valmet Automotiven organisaatiota. Referred 5.4.2018. www.valmet-automotive.com/automotive/bulletin.nsf/PFBD/2C9058E6B3531D26C2257FE10028E77C?opendocument

Valmet Automotive 2017a. Valmet Automotive ja CATL strategiseen kumppanuuteen sähköautoratkaisuissa – Samalla CATL merkittäväksi omistajaksi Valmet Automotiveen. Referred 5.4.2018. www.valmet-automotive.com/automotive/bulletin.nsf/PFBD/9B12CB6F9E7B7A6DC22580B8002D8E75?opendocument

Valmet Automotive 2017b. Valmet Automotive alkaa valmistamaan akkuja Avant Tecnolle. Referred 5.4.2018. www.valmet-automotive.com/automotive/bulletin.nsf/pebd/DF88A6706AAF1C7AC22581A600295F47

Valmet Automotive 2018a. Valmet Automotive set a new production record in 2017 with 90 000 cars. Referred 12.4.2018. www.valmet-automotive.com/automotive/bulletin.nsf/pbic/20180329023

Valmet Automotive 2018b. Logistiikka ja tuotannonohjaus. Referred 5.4.2018. www.valmet-automotive.com/automotive%5Ccms.nsf/pages/642EC8C5D3564859C2257BEB003CD712?opendocument

Vartiainen, M. 1994. Työn muutoksen työvälineet. Helsinki: Otatieto.

Vuorela, A. 2017. Suomen ennätysrekrytointi: 2000 henkilöä yhdeksässä kuukaudessa – Valmet Automotive palkittiin Suomen Kasvupalkinnolla. Yle Uutiset. Referred 5.4.2018. https://yle.fi/uutiset/3-9900727

Interview

The interview conducted in 20.3.2018 for the internal logistics development team, in the responsibility of Kalle Karvanen and Juhani Kerminen. The answers were received in 5.4.2018 via email, which are referred to throughout the paper. In these cases, either Karvanen or Kerminen is marked as source, depending on the question.

1.1 20.3.2018

valmet automotive

NIMI: ____________________

TITTELI VA:LLA: ____________________

KOKEMUS PFEP:ISTÄ: ____________________

1. PFEP

   A. Base-info

      1. Miten kuvailisit PFEP:in vaikutusta yrityksen toimintaan, ja sen kehittämiseen?
      2. Mitä yleisimpiä hyötyjä PFEP tuo mukanaan?
      3. Kuten monet työkalut PFEP yhdistää dataa useista eri lähteistä. Mikä on paras tapa mielestäsi?
      4. Mitkä ovat kaikkein haasteellisimpia tilanteita, mitä PFEP voi, tai yleisimmin tuo mukanaan?
      5. Mihin liittyvät esimerkki-ongelmatilanteet?

   B. Lean

      1. Miten leanin mukainen toiminen näkyy VA:lla: prosesseissa, toimintatavoissa, sisälogistiikan kehitystoimissa?
      2. Miten lean-arvojen toteutumista seurataan ja kehitetään?
      3. Teesi: PFEP kuuluu lean-filosofiaan, ja on yksi olennaisimmista askeleista lean transformatiossa
         - Mitä mieltä ja millä perusteella?
         - Onko yhteyksiä muihin toiminta-tuotantomalleihin? Mihin ja miten?

1.1 20.3.2018

2. Case: VA, picking process

A. Nyt

1. Miten kuvailisit sisälogistiikan kehitystoimia / projekteja tällä hetkellä?
   - Missä on fokus?
   - Miten organisaatiomuutos on vaikuttanut / tulee vaikuttamaan toimintaan?
   - Miten uuden automallin tuotanto on vaikuttanut / tulee vaikuttamaan toimintaan?
   - Mitkä ovat tulevaisuuden haasteita, ja miten niitä aiotaan selvittää?
   - Miten suurta huomiota keruuosat saavat projekteissa?
2. Miten osatietoja käytetään tällä hetkellä hyödyksi?
   - Miten niitä voisi käyttää hyödyksi paremmin?
   - Entä miten niitä hyödynnetään erityisesti keruuprosessissa?
3. Miten työntutkimuksen tuloksia käytetään tällä hetkellä hyödyksi?
   - Miten niitä voisi käyttää hyödyksi paremmin?
   - Entä miten niitä hyödynnetään erityisesti keruuprosessissa?
4. Miten nykyistä PFEP:iä käytetään tällä hetkellä / on käytetty aiemmin hyödyksi?
   - Miten sitä voisi käyttää hyödyksi paremmin (tämän projektin tavoitteiden lisäksi)?
   - Entä miten niitä hyödynnetään erityisesti keruuprosessissa?

B. Uusi

1. PFEP kuvastaa jokaisen yrityksen ominaispiirteitä. Mihin seikkoihin on kiinnitettävä erityistä huomiota laadittaessa PFEP:iä VA:lle? Miksi?
   - Entä mikä tekee VA:n keruuprosesseista erityislaatuisen? Onko se erityislaatuinen?
2. Mikä on keskeisin käyttökohde / kehitystoimi, johon PFEP on välttämätön työkalu?
   - Mihin muuhun työkalua voi käyttää?
   - Millaisia suunnitelmia VA:n sisälogistiikalla on PFEP:in käytölle, kehitykselle ja jatkojalostukselle?